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Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains

Supplementary Seismic Hazard Results for Sites with Multiple Soil Conditions

Prepared by D.L. Bernreuter, J.B. Savy, R.W. Mensing, J.C. Chen

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Prepared for
U.S. Nuclear Regulatory Commission

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Abstract

The EUS Seismic Hazard Characterization Project (SHC) is the outgrowth of an earlier study performed as part of the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP). The objectives of the SHC were: (1) to develop a seismic hazard characterization methodology for the region east of the Rocky Mountains (EUS), and (2) the application of the methodology to 69 site locations, some of them with several local soil conditions. The method developed uses expert opinions to obtain the input to the analyses. An important aspect of the elicitation of the expert opinion process was the holding of two feedback meetings with all the experts in order to finalize the methodology and the input data bases. The hazard estimates are reported in terms of peak ground acceleration (PGA) and 5% damping velocity response spectra (PSV).

A total of eight volumes make up this report which contains a thorough description of the methodology, the expert opinion's elicitation process, the input data base as well as a discussion, comparison and summary volume (Volume VI).

Consistent with previous analyses, this study finds that there are large uncertainties associated with the estimates of seismic hazard in the EUS, and it identifies the ground motion modeling as the prime contributor to those uncertainties.

The data bases and software are made available to the NRC and to public uses through the National Energy Software Center (Argonne, Illinois).

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Foreword

The impetus for this study came from two unrelated needs of the Nuclear Regulatory Commission (NRC). One stimulus arose from the NRC funded "Seismic Safety Margins Research Programs" (SSMRP). The SSMRP's task of simplified methods needed to have available data and analysis software necessary to compute the seismic hazard at any site located east of the Rocky Mountains which we refer to as the Eastern United States (EUS) in a form suitable for use in probabilistic risk assessment (PRA). The second stimulus was the result of the NRC's discussions with the U.S. Geological Survey (USGS) regarding the USGS's proposed clarification of their past position with respect to the 1886 Charleston earthquake. The USGS clarification was finally issued on November 18, 1982, in a letter to the NRC, which states that:

> "Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient ground for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

Anticipation of this letter led the Office of Nuclear Reactor Regulation to jointly fund a project with the Office of Nuclear Regulatory Research. The results were presented in Bernreuter et. al., (1985), and the objectives were:

1. to develop a seismic hazard characterization methodology for the entire region of the United States east of the Rocky Mountains.

2. to apply the methodology to selected sites to assist the NRC staff in their assessment of the implications in the clarification of the USGS position on the Charleston earthquake, and the implications of the occurrence of the recent earthquakes such as that which occurred in New Brunswick, Canada, in 1982.

The methodology used in that 1985 study evolved from two earlier studies that the Lawrence Livermore National Laboratory (LLNL) performed for the NRC. One study, Bernreuter and Minichino (1983), was part of the NRC's Systematic Evaluation Program (SEP) and is simply referred hereafter to as the SEP study. The other study was part of the SSMRP.

At the time (1980-1985), an improved hazard analysis methodology and EUS seismicity and ground motion data set were required for several reasons:

- o Although the entire EUS was considered at the time of the SEP study, attention was focused on the areas around the SEP sites--mainly in the Central United States (CUS) and New England. The zonation of other areas was not performed with the same level of detail.

- o The peer review process, both by our Peer Review Panel and other reviewers, identified some areas of possible improvements in the SEP methodology.

- o Since the SEP zonations were provided by our EUS Seismicity Panel in early 1979, a number of important studies had been completed and several significant EUS earthquakes had occurred which could impact the Panel members' understanding of the seismotectonics of the EUS.

- o Our understanding of the EUS ground motion had improved since the time the SEP study was performed.

By the time our methodology was firmed up, the expert opinions collected and the calculations performed (i.e. by 1985), the Electric Power Research Institute (EPRI) had embarked on a parallel study.

We performed a comparative study, Bernreuter et. al., (1987), to help in understanding the reasons for differences in results between the LLNL and the EPRI studies. The three main differences were found to be: (1) the minimum magnitude value of the earthquakes contributing to the hazard in the EUS, (2) the ground motion attenuation models, and (3) the fact that LLNL accounted for local site characteristics and EPRI did not. Several years passed between the 1985 study and the application of the methodology to all the sites in the EUS. In recognition of the fact that during that time a considerable amount of research in seismotectonics and in the field of strong ground motion prediction, in particular with the development of the so called random vibration or stochastic approach, NRC decided to follow our recommendations and have a final round of feedback with all our experts prior to finalizing the input to the analysis.

In addition, we critically reviewed our methodology which lead to minor improvements and we also provided an extensive account of documentation on the ways the experts interpreted our questionnaires and how they developed their answers. Some of the improvements were necessitated by the recognition of the fact that the results of our study will be used, together with results from other studies such as the EPRI study or the USGS study, to evaluate the relative hazard between the different plant sites in the EUS.

This report includes eight volumes:

> Volume I provides an overview of the methodology we developed for this project. It also documents the final makeup of both our Seismicity and Ground Motion Panels, and documents the final input from the members of both panels used in the analysis. Comparisons are made between the new results and previous results.

Volumes II to V provide the results for all the active nuclear power plant sites of the EUS divided into four batches of approximately equal size and of sites roughly located in the four main geographical regions of the EUS (NE,1 SE, NC and SC). A regional discussion is given in each of Vols. II to V.

Volume VI emphasizes important sensitivity studies, in particular the sensitivity of the results to correction for local site conditions and G-Expert 5's ground motion model. It also contains a summary of the results and provides comparisons between the sites within a common region and for sites between regions.

Volume VII contains unaltered copies of the ten questionnaires used from the beginning of the 1985 study to develop the complete input for this analysis.

After the bulk of the work was completed and draft reports for Vols. I-VII were written, additional funding became available.

Volume VIII contains the hazard result for the 12 sites which were primarily rock sites but which also had some structures founded on shallow soil. These results supplement the results given in Vols. II to V where only the primary soil condition at the site was used.

List of Abbreviations and Symbols

A	Symbol for Seismicity Expert 10 in the figures displaying the results for the S-Experts
ALEAS	Computer code to compute the BE Hazard and the CP Hazard for each seismicity expert
AM	Arithmetic mean
AMHC	Arithmetic mean hazard curve
B	Symbol for Seismicity Expert 11 in the figures displaying the results for the S-Experts
BE	Best estimate
BEHC	Best estimate hazard curve
BEUHS	Best estimate uniform hazard spectrum
BEM	Best estimate map
C	Symbol for Seismicity Expert 12 in the figures displaying the results for the S-Experts
COMAP	Computer code to generate the set of all alternative maps and the discrete probability density of maps
COMB	Computer code to combine BE hazard and CP hazard over all seismicity experts
CP	Constant percentile
CPHC	Constant percentile hazard curve
CPUHS	Constant percentile uniform hazard spectrum
CUS	Central United States, roughly the area bounded in the west by the Rocky Mountains and on the east by the Appalachian Mountains, excluding both mountain systems themselves
CZ	Complementary zone
D	Symbol for Seismicity Expert 13 in the figures displaying the results for the S-Experts
EPRI	Electric Power Research Institute

EUS	Used to denote the general geographical region east of the Rocky Mountains, including the specific region of the Central United States (CUS)
g	Measure of acceleration: 1g = 9.81m/s/s = acceleration of gravity
G-Expert	One of the five experts elicited to select the ground motion models used in the analysis
GM	Ground motion
HC	Hazard curve
I_o	Epicentral intensity of an earthquake relative to the MMI scale
I_s	Site intensity of an earthquake relative to the MMI scale
LB	Lower bound
LLNL	Lawrence Livermore National Laboratory
M	Used generically for any of the many magnitude scales but generally m_b, $m_b(Lg)$, or M_L.
M_L	Local magnitude (Richter magnitude scale)
M_b	True body wave magnitude scale, assumed to be equivalent to $m_b(Lg)$ (see Chung and Bernreuter, 1981)
$m_b(Lg)$	Nuttli's magnitude scale for the Central United States based on the Lg surface waves
M_S	Surface wave magnitude
MMI	Modified Mercalli Intensity
M_o	Lower magnitude of integration. Earthquakes with magnitude lower than M_o are not considered to be contributing to the seismic hazard
NC	North Central; Region 3
NE	North East; Region 1
NRC	Nuclear Regulatory Commission
PGA	Peak ground acceleration
PGV	Peak ground velocity

PRD Computer code to compute the probability distribution of epicentral distances to the site

PSRV Pseudo relative velocity spectrum. Also see definition of spectra below

Q Seismic quality factor, which is inversely proportional to the inelastic damping factor.

Q1 Questionnaire 1 - Zonation (I)

Q2 Questionnaire 2 - Seismicity (I)

Q3 Questionnaire 3 - Regional Self Weights (I)

Q4 Questionnaire 4 - Ground Motion Models (I)

Q5 Questionnaire 5 - Feedback on seismicity and zonation (II)

Q6 Questionnaire 6 - Feedback on ground motion models (II)

Q7 Questionnaire 7 - Feedback on zonation (III)

Q8 Questionnaire 8 - Seismicity input documentation

Q9 Questionnaire 9 - Feedback on seismicity (III)

Q10 Questionnaire 10 - Feedback on ground motion models (III)

R Distance metric, generally either the epicentral distance from a recording site to the earthquake or the closest distance between the recording site and the ruptured fault for a particular earthquake.

Region 1 (NE): North East of the United States, includes New England and Eastern Canada

Region 2 (SE): South East United States

Region 3 (NC): North Central United States, includes the Northern Central portions of the United States and Central Canada

Region 4 (SC): Central United States, the Southern Central portions of the United States including Texas and Louisiana

RP Return period in years.

RV Random vibration. Abbreviation used for a class of ground motion models also called stochastic models.

S	Site factor used in the regression analysis for G-Expert 5's GM model: S = 0 for deep soil, S = 1 for rock sites
SC	South Central; Region 4
SE	South East; Region 2
S-Expert	One of the eleven experts who provide the zonations and seismicity models used in the analysis
SEP	Systematic Evaluation Program
SHC	Seismic Hazard Characterization
SHCUS	Seismic Hazard Characterization of the United States
SN	Site Number
Spectra	Specifically in this report: attenuation models for spectral ordinates were for 5% damping for the pseudo-relative velocity spectra in PSRV at five frequencies (25, 10, 5, 2.5, 1 Hz).
SSE	Safe Shutdown Earthquake
SSI	Soil-structure-interaction
SSMRP	Seismic Safety Margins Research Program
UB	Upper bound
UHS	Uniform hazard spectrum (or spectra)
USGS	United States Geological Survey
WUS	The regions in the Western United States where we have strong ground motion data recorded and analyzed

Executive Summary: Volume VIII

After the completion of the analysis reported in Vols. II-V and summarized in Vol. VI, some additional funds became available. Because of the importance of the correction for local site conditions, it was determined that it would be most beneficial to use these funds to perform an analysis for the appropriate shallow soil category at the twelve sites which had most structures founded on rock but also had a few founded on shallow soil. These sites and their secondary soil categories are listed in Table 1.1.

In Sections 2.1 to 2.12 we provide the results for the secondary soil category for the sites listed in Table 1.1. Using a uniform format for each site (i.e., each section) we first present Table 2.SN.1 (where "SN" stands for Site Number) providing the following information:

- o Secondary soil category used in the analysis to correct for local site conditions.

- o For each S-Expert the Table 2.SN.1 provides a listing of the four seismic zones which contribute most to the hazard in terms of the peak ground acceleration (PGA) at both lower PGA (0.125g) and at higher PGA (0.6g) values.

The contribution of various zones given in the table for each site is limited only to the contribution to the best estimate hazard curves (BEHCs).

The table is followed by Figs. 2.SN.1 to 2.SN.11 (SN = Site Number given in Table 1.1). The first three figures, Figs. 2.SN.1 - 2.SN.3 give various PGA hazard curves. Figure 2.SN.4 gives a comparison between the CPHCs for the shallow soil compared to the rock case. The next six figures, Figs. 2.SN.5 - 2.SN.10 give various 5 percent damped relative velocity spectra for various return periods. It should be noted that the spectral calculations have only been made at five periods, 0.04s, 0.1s, 0.2s, 0.4s, and 1.0s and straight lines have been used to connect these points to get the shapes plotted. Figures 2.SN.11 give a comparison between the 15th, 50th and 85th percentile CPUHS between the shallow soil case and the rock case.

In Section 3 we examine the regional variation of the effects of the site correction on the computed hazard. We also examine the sensitivity of the results to the choice of ground motion models, in particular, relative to the low attenuation model selected by G-Expert 5.

Our results show several interesting somewhat unexpected results:

- o There can be a wide region-to-region and even site-to-site variation in how the site correction impacts the computed hazard at a site. We found that the computed median hazard applicable for the structures founded in shallow soil range over a factor of 2 to over 5 higher than the median hazard applicable for structures founded on rock at the same site. Given this wide variation and the complex set of

factors causing the variation, it is not possible to say without doubt that our results include the worst case.

- It is clear from the results presented that it is not possible to approximately correct for site conditions by first computing the hazard at a site by considering it as a rock site and then introduce approximate correction factors, e.g., such as could be extracted from the sensitivity results given in Section 2.2 of Vol. VI.

- Considerable caution must be exercised in trying to use the results given in this volume to extrapolate to other sites. There is a very complex interaction between the zonation, seismicity parameters and the correction for site type which has a significant impact on the computed hazard at any given site.

- The correction for site category is sensitive to the ground motion models used. If G-Expert 5's model is not included then it appears that there is a wider regional and site-to-site variation than when G-Expert 5's model is included.

1. INTRODUCTION

In Vol. I of this report, we provided a discussion of our methodology, including the approach used to account for local soil conditions. In Vol. I we also provided the input provided by both our S- and G-Experts. In Vols. II-V we provided the results of our seismic hazard analysis for all active nuclear power plant sites in the EUS.

At most of the sites analyzed in Vols. II-V the critical structures were all founded on the same category of soil. However, at the twelve sites listed in Table 1.1, some critical structures were founded on shallow soil although most critical structures were founded on rock. Table 1.1 also indicates the location in this report of the results for the primary analysis, it gives the type of soil category of that primary analysis, and in addition, it provides a comparison of the results between the results at the shallow soil and its primary (rock) soil condition. This comparison is given in terms of both the ratio of probability of exceedance of 0.3g between shallow and rock, and the average ratio of the PGA value for three fixed probabilities of exceedance (10^{-3}, 10^{-4} and 10^{-5}). A complete discussion of these results is given in Section 3.1. In Fig. 1.1 we show the location of these sites. The results in Vols. II-V, for these twelve sites, were applicable only for the structures founded on rock. In Section 2 of Vol. VI we presented a sensitivity study showing the importance of correcting for local soil conditions and we noted that generic corrections could not be used in general because there was some regional site-to-site variation.

In Section 2 of this report we present the results for each of the sites for the secondary soil conditions listed in Table 1.1. Also included for each site is a comparison between the hazard applicable for the structures founded in rock and those founded on shallow soil. In Section 3 we make comparisons between the sites and show that the correction can vary considerably between sites.

TABLE 1.1

LIST OF SITES WITH SOME STRUCTURES FOUNDED ON ROCK AND SOME ON SHALLOW SOIL

Section Number	Site Name	Soil Category in Vols. II-V	Results in	Secondary Soil Category	Ratios Soil/Rock(*)		Plot Symbol
					Average Ratio of PGAs at $10^{-3}, 10^{-4}, 10^{-5}$ Probability	CPHCs at 0.3g	
1	Nine Mile Point	Rock	Vol. II 2.9	Sand-1	1.58	4.3	1
2	Susquehanna	Rock	Vol. II 2.16	Till-2	1.30	2.1	2
3	Three Mile Island	Rock	Vol. II 2.17	Sand-1	1.47	2.4	3
4	Browns Ferry	Rock	Vol. III 2.2	Sand-1	1.63	5.1	4
5	Catawba	Rock	Vol. III 2.5	Sand-1	1.58	3.6	5
6	Farley	Rock	Vol. III 2.6	Sand-1	1.53	3.0	6

TABLE 1.1
(CONTINUED)

LIST OF SITES WITH SOME STRUCTURES FOUNDED
ON ROCK AND SOME ON SHALLOW SOIL

Section Number	Site Name	Soil Category in Vols. II-V	Results in	Secondary Soil Category	Ratios Soil/Rock(*)		Plot Symbol
					Average Ratio of PGAs at 10^{-3}, 10^{-4}, 10^{-5} Probability	CPHCs at 0.3g	
7	North Anna	Rock	Vol. III 2.9	Sand-1	1.51	3.0	7
8	Oconee	Rock	Vol. III 2.10	Sand-1	1.43	2.7	8
9	Summer	Rock	Vol. III 2.14	Sand-1	1.57	3.6	9
10	Arkansas	Rock	Vol. V 2.1	Till-1	1.51	2.5	A
11	Callaway	Rock	Vol. V 2.2	Sand-1	1.69	5.1	B
12	Duane Arnold	Rock	Vol. V 2.6	Till-1	1.50	3.1	C

(*) Note: For details on the calculations of the ratios, see Section 3.1.

Figure 1.1 Map showing the location of the sites with structures founded on both rock and shallow soil. Map symbols are given in Table 1.1.

2. RESULTS AND SITE SPECIFIC DISCUSSION

2.0 General Introduction

In Sections 2.1 to 2.12 we provide the results for the secondary soil category for the sites listed in Table 1.1. Using a uniform format for each site (i.e., each section) we first present table 2.SN.1 (where "SN" stands for Site Number) providing the following information:

- Secondary soil category used in the analysis to correct for local site conditions.

- For each S-Expert the table 2.SN.1 provides a listing of the four seismic zones which contribute most to the hazard in terms of the peak ground acceleration (PGA) at both lower PGA (0.125g) and at higher PGA (0.6g) values. The zone ID's listed in tables are keyed to the S-Experts' maps given in Appendix B of this volume.

The contribution of various zones given in the table for each site is limited only to the contribution to the best estimate hazard curves (BEHCs). That is, only the zones on the best estimate (BE) map (i.e., those zones which have a probability of existence of 0.5 or greater) and only the BE PGA models are used. This, as is discussed in Section 3.3 of Vols. II-V, is a limitation that should be kept in mind as in a few cases, zones with a probability of existence of less than 0.5 which may contribute might not be listed in Table 2.SN.1.

The table is followed by Figs. 2.SN.1 to 2.SN.11 (SN = Site Number given in Table 1.1). The first four figures, Figs. 2.SN.1 - 2.SN.4 give various PGA hazard curves. The next six figures, Figs. 2.SN.5 - 2.SN.10 give various 5 percent damped pseudo relative velocity spectra for various return periods. It should be noted that the spectral calculations have only been made at five periods, 0.04s, 0.1s, 0.2s, 0.4s, and 1.0s and straight lines have been used to connect these points to get the shapes plotted.

Figures 2.SN.1 give a comparison between the best estimate hazard curve (BEHC) and the arithmetic mean hazard curve (AMHC) for the peak ground acceleration (PGA). The BEHC and the AMHC are aggregated over all S- and G-Experts and include the experts' self weights. Reference should be made to Section 2 and Appendix C of Vol. 1 for a discussion about these two estimators. Briefly, in our elicitation process we asked each S-Expert to indicate which set of zones he considered his "best estimate" in the sense that it represented the mode of the distribution of all his choices and similarly for the best estimate values for all of the seismicity parameters for each zone. We also asked each G-Expert to indicate which ground motion model represented his best estimate model. Then, as indicated in Vol. I, the set of best estimate zones and seismicity parameters are used with each of the best estimate ground motion models to generate 55 BEHCs' (11 S-Experts and 5 G-Experts make 55 pairs). These 55 curves are then aggregated using both the S- and G-Experts' self weights. The AMHC is generated in the usual manner using all 2750 simulations of the Monte Carlo analysis.

Figures 2.SN.2 give the BEHC for each S-Expert aggregated over the five G-Experts. Whenever individual S-Experts' hazard curves are plotted they are denoted by the plot key given in Table 2.0. Figure 2.SN.2 gives a measure of the range of difference of opinion between the S-Experts.

Figures 2.SN.3 give the 15th, 50th and 85th constant percentile hazard curves (CPHCs) based on all 2750 simulations and give a measure of the overall uncertainty.

Figures 2.SN.4 give a comparison between the CPHCs for the secondary soil category as compared to the rock case reported previously in Vols. II-V. This comparison shows the impact on the seismic hazard of the correction for local soil conditions for the structures founded on shallow soil.

Figures 2.SN.5 give the best estimate uniform hazard spectra (BEUHS) for return periods of 500, 1000, 2000, 5000, and 10,000 years, aggregated over all S-and G-Experts.

Figures 2.SN.6 give the 1000 year return period BEUHS for each of the S-Experts, aggregated over the G-Experts. The S-Experts' BEUHS are plotted using the symbols in Table 2.0. These plots give a good measure of the significance of the differences in opinion between the S-Experts.

Figures 2.SN.7,8,9 give the 15th, 50th and 85th constant percentile uniform hazard spectra (CPUHS) aggregated over all S- and G-Experts for return periods of 500, 1000 and 10,000 years. The spread between the 15th and 85th CPUHS gives a good measure of the overall uncertainty in the estimate of the seismic hazard at the site.

Figures 2.SN.10 give the 50th CPUHS for return periods of 500, 1000, 2000, 5000 and 10,000 years, aggregated over all S- and G-Experts.

Figures 2.SN.11 give a comparison between the 15th, 50th and 85th percentile CPUHS between the shallow soil case and the rock case.

A separate discussion is given when some factors of interest are noted. In Section 3 comparisons between the sites and general observations are made.

TABLE 2.0

PLOT SYMBOL KEY USED FOR INDIVIDUAL
S-EXPERTS ON FIGS. 2.SN.2 AND 2.SN.6

Expert No.	Plot Symbol
1	1
2	2
3	3
4	4
5	5
6	6
7	7
10	A
11	B
12	C
13	D

2.1 Nine Mile Point

The location of the Nine Mile Point site is shown in Fig. 1.1 by the plot symbol "1". Most of the structures at the Nine Mile Point site are founded on rock. The hazard results for the rock case are given in Section 2.9 of Vol. II. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Nine Mile Point site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.1.1 and Figs. 2.1.1 to 2.1.11 give the basic results most applicable to the structures founded on shallow soil at the Nine Mile Point site.

If comparisons are made between Table 2.1.1 and Table 2.9.1 of Vol. II we see some changes. Primarily, the shallow soil amplifies the ground motion from smaller nearby earthquakes making the local zones more significant thereby producing a motion relatively richer in high frequency energy than would the rock site, (see Fig. 2.1.11); e.g., for S-Expert 2 the CZ, which is the S-Expert 2's host zone (i.e., the zone in which the site is located for the particular S-Expert), is indicated to be the most significant contributor in Table 2.1.1, whereas on Table 2.9.1 of Vol. II zone 32 is the most significant contributor. Similarly we see that in Table 2.1.1 for S-Expert 7 at the higher g levels zone 41 becomes the most significant contributor as compared to zones 17 and 41 in Table 2.9.1 of Vol. II.

We see from Fig. 2.1.4 that the median CPHC applicable to the structures founded on the shallow soil is significantly higher than the median CPHC applicable to the structure founded on rock for the Nine Mile Point site.

However, when discussing site amplification, one must be careful to compare ground motion parameter values rather than the probabilities of exceedance. Here the 1000 year return period PGA for rock is a factor of 1.6 (approximately) smaller than for the shallow soil. This can be seen on Fig. 2.1.4 by making the ratio of PGA values for a constant probability of exceedance of 10^{-3}. The same ratio can be found at 10,000 and 100,000 year return periods. Thus, we would say that the average amplification due to existence of shallow soil at this site is very close to the average ratio of 1.55 we might expect (see Section 3.1 for more details on this point).

Similarly we see from Fig. 2.1.11 that the 10,000 year return period median CPUHS is significantly higher for the shallow soil case as compared to the rock case. There is a much smaller difference between the 85th percentiles for the two cases. These results are in general agreement with the discussion given in Section 2.2 of Vol. VI.

TABLE 2.1.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR NINE MILE POINT S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 15	ZONE ID:	ZONE 20	ZONE 19	ZONE 21	ZONE 15	ZONE 20	ZONE 19	ZONE 15	ZONE 21
		% CONT.:	74.	10.	8.	4.	80.	9.	8.	2.
2	COMP. ZO	ZONE ID:	ZONE 32	COMP. ZON	ZONE 31	ZONE 28	COMP. ZON	ZONE 32	ZONE 31	ZONE 27
		% CONT.:	61.	25.	12.	2.	50.	49.	1.	0.
3	ZONE 11	ZONE ID:	ZONE 11	ZONE 2	ZONE 3	ZONE 4	ZONE 11	ZONE 2	COMP. ZON	ZONE 3
		% CONT.:	80.	17.	2.	1.	96.	4.	0.	0.
4	ZONE 13	ZONE ID:	ZONE 16	ZONE 19	ZONE 13	ZONE 15	ZONE 16	ZONE 13	COMP. ZON	ZONE 19
		% CONT.:	85.	5.	3.	3.	93.	7.	0.	0.
5	COMP. ZO	ZONE ID:	ZONE 6	ZONE 5	ZONE 4	ZONE 3	ZONE 6	ZONE 5	ZONE 4	COMP. ZON
		% CONT.:	94.	3.	2.	0.	91.	4.	3.	1.
6	COMP. ZO	ZONE ID:	ZONE 7	ZONE 3	ZONE 8	COMP. ZON	ZONE 7	COMP. ZON	ZONE 3	ZONE 8
		% CONT.:	86.	7.	3.	3.	94.	5.	0.	0.
7	ZONE 41	ZONE ID:	ZONE 17	ZONE 41	ZONE 18	ZONE 26	ZONE 41	ZONE 17	ZONE 18	ZONE 2 =
		% CONT.:	54.	25.	16.	3.	61.	35.	3.	0.
10	ZONE 19	ZONE ID:	ZONE 19 =	ZONE 6	ZONE 7	ZONE 9	ZONE 19 =	ZONE 6	ZONE 7	ZONE 9
		% CONT.:	55.	25.	11.	4.	94.	5.	1.	0.
11	CZ = ZON	ZONE ID:	CZ = ZONE	ZONE 3	ZONE 4	ZONE 5	CZ = ZONE	ZONE 4	ZONE 3	ZONE 9
		% CONT.:	32.	30.	28.	4.	66.	26.	7.	1.
12	ZONE 4 =	ZONE ID:	ZONE 31	ZONE 30	ZONE 34	ZONE 31A	ZONE 31	ZONE 30	ZONE 34	ZONE 17
		% CONT.:	64.	26.	8.	1.	77.	20.	3.	0.
13	CZ 15	ZONE ID:	CZ 15	ZONE 11	ZONE 12	ZONE 10	CZ 15	ZONE 11	ZONE 12	ZONE 7
		% CONT.:	60.	25.	14.	1.	98.	1.	0.	0.

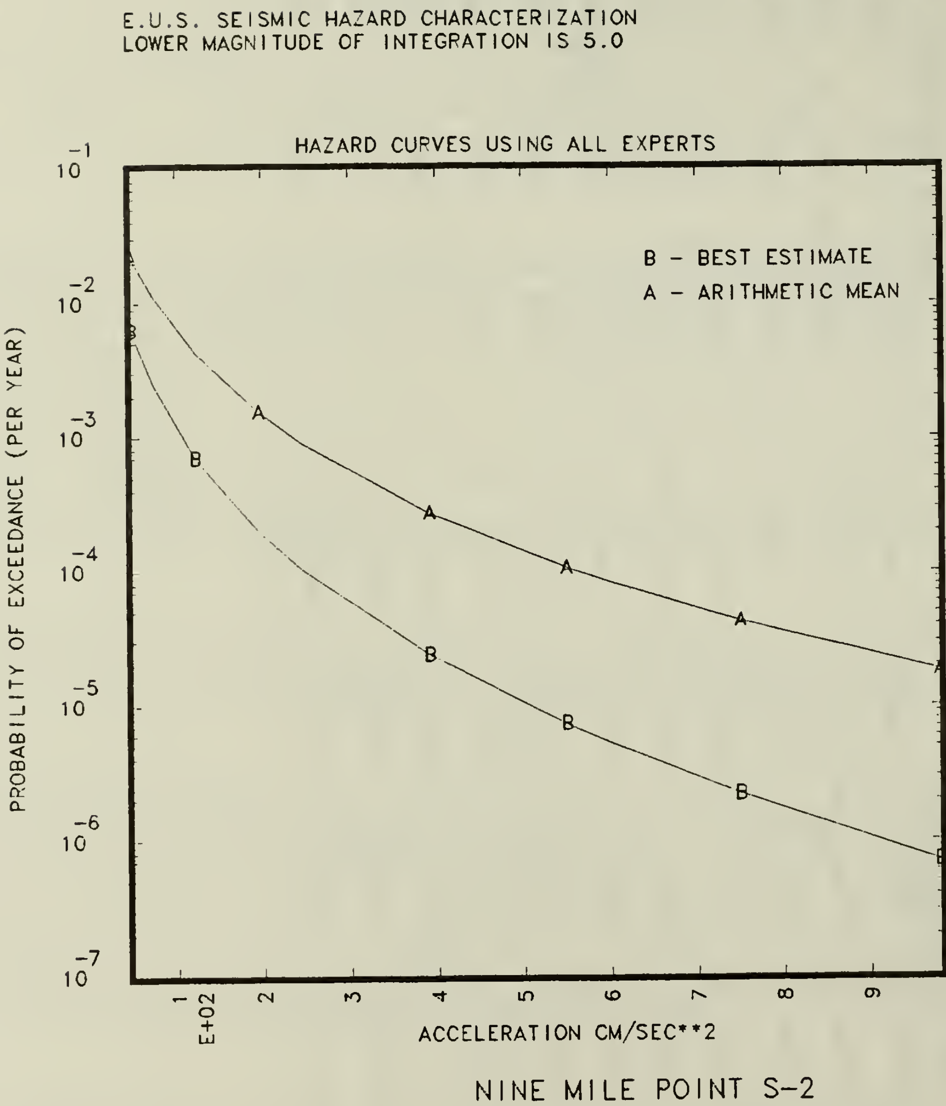


Figure 2.1.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Nine Mile Point site.

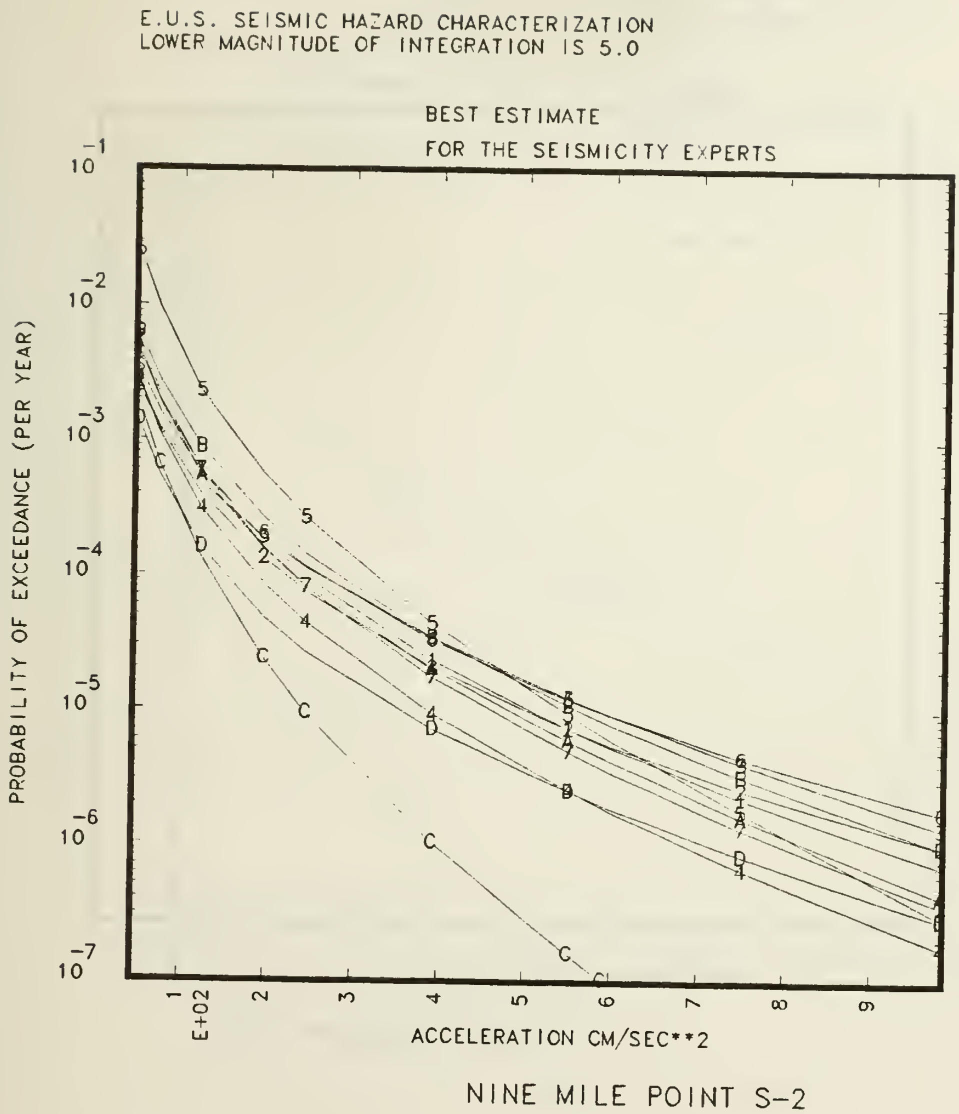


Figure 2.1.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Nine Mile Point site. Plot symbols given in Table 2.0.

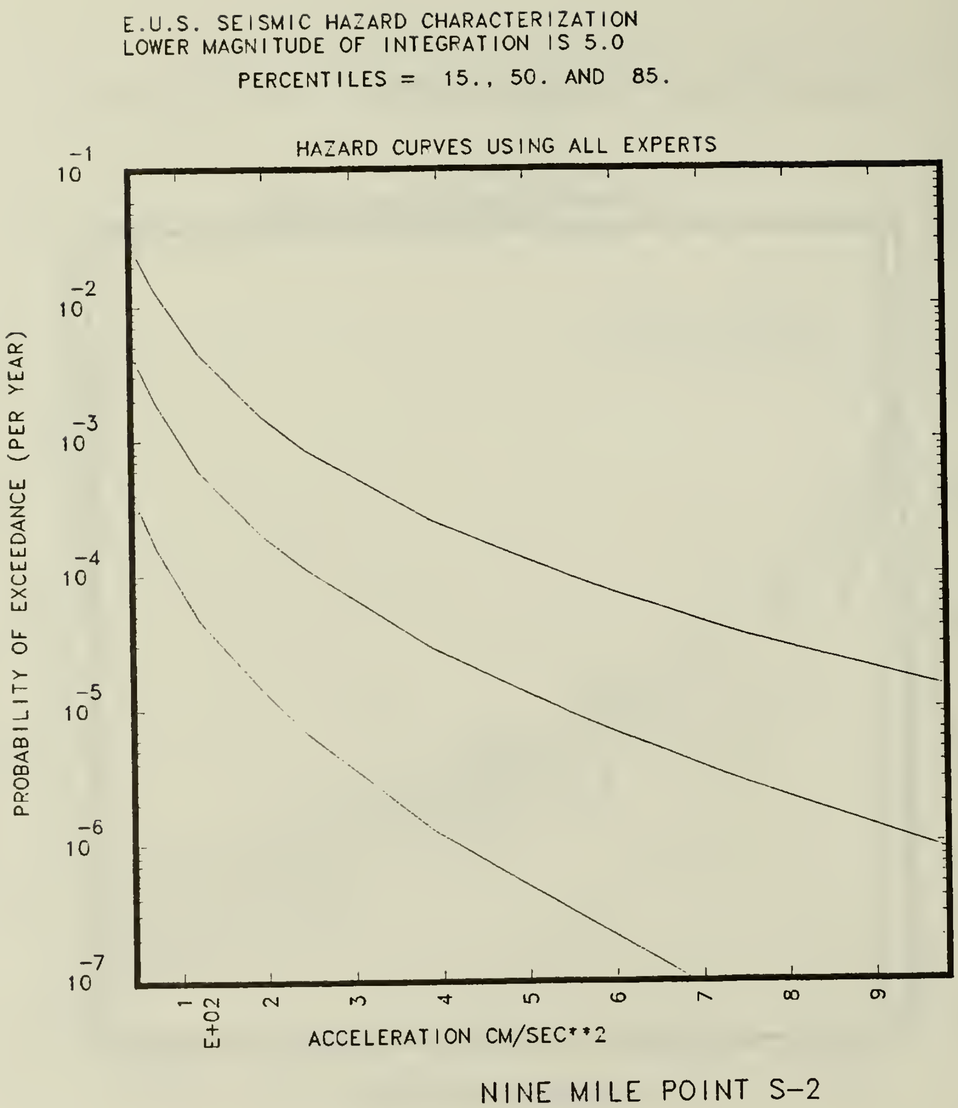


Figure 2.1.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Nine Mile Point site.

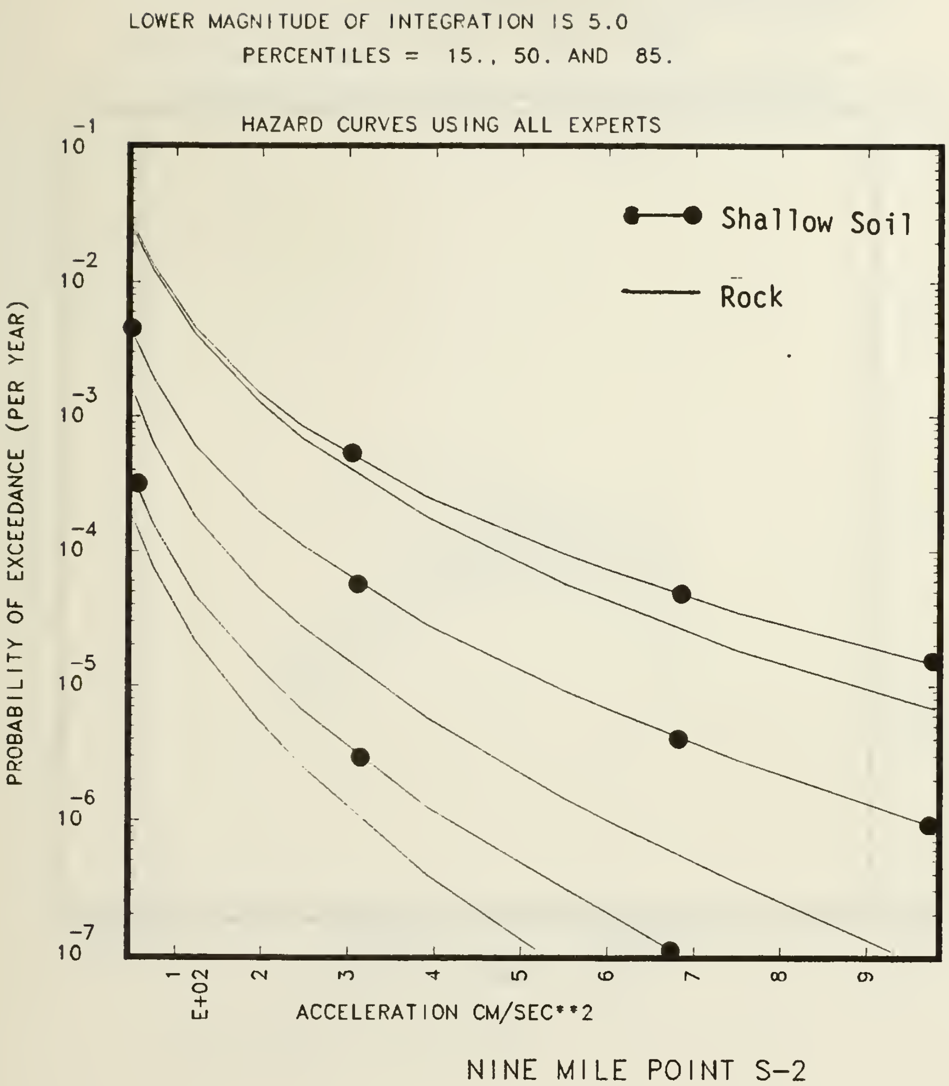


Figure 2.1.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Nine Mile Point site.

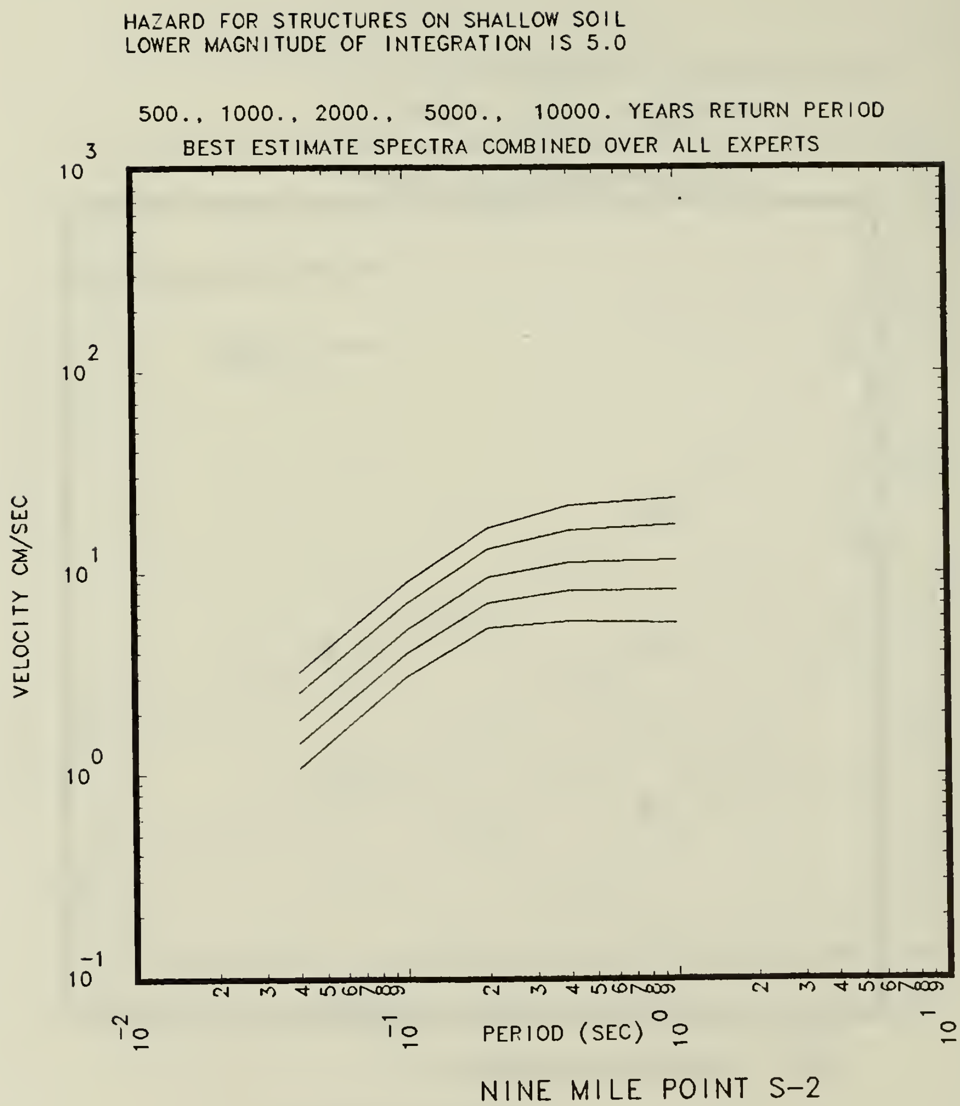


Figure 2.1.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Nine Mile Point site.

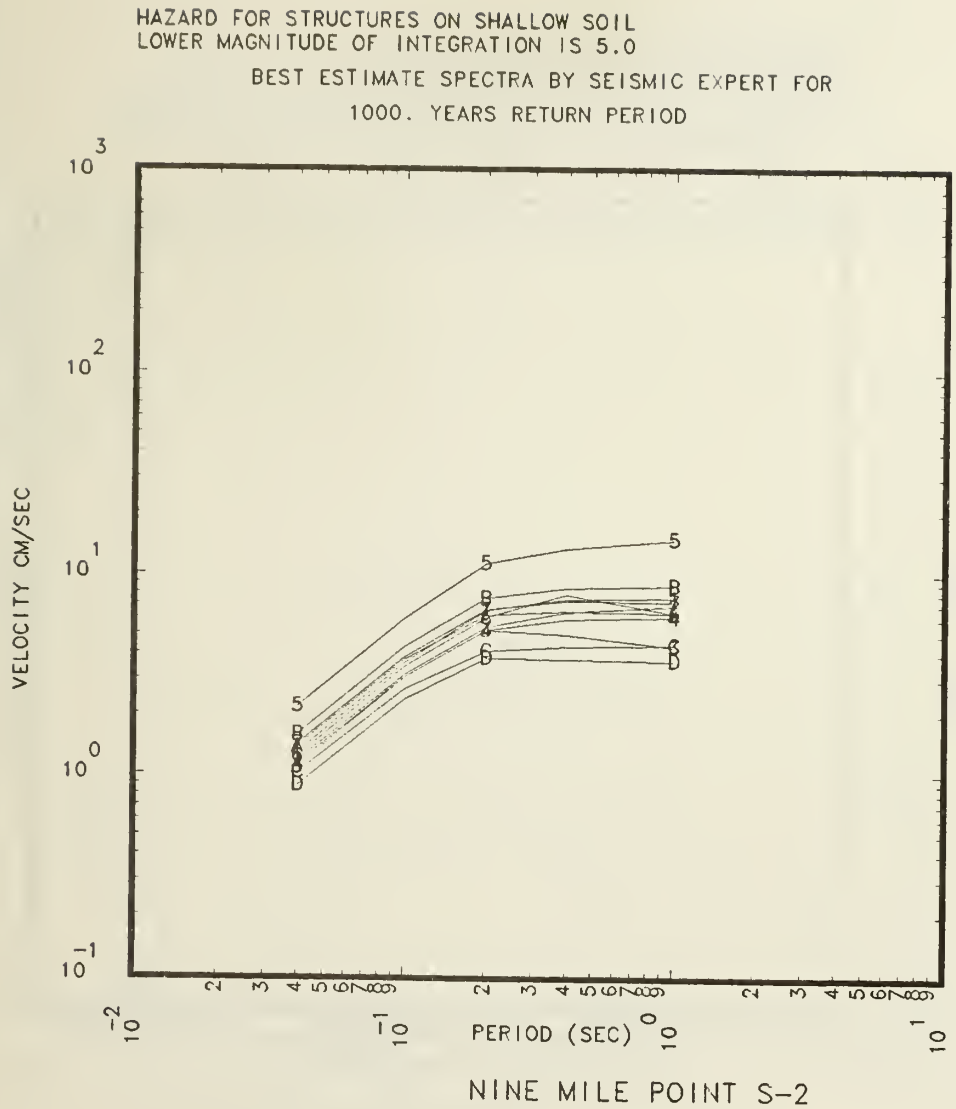


Figure 2.1.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Nine Mile Point site. Plot symbols are given in Table 2.0

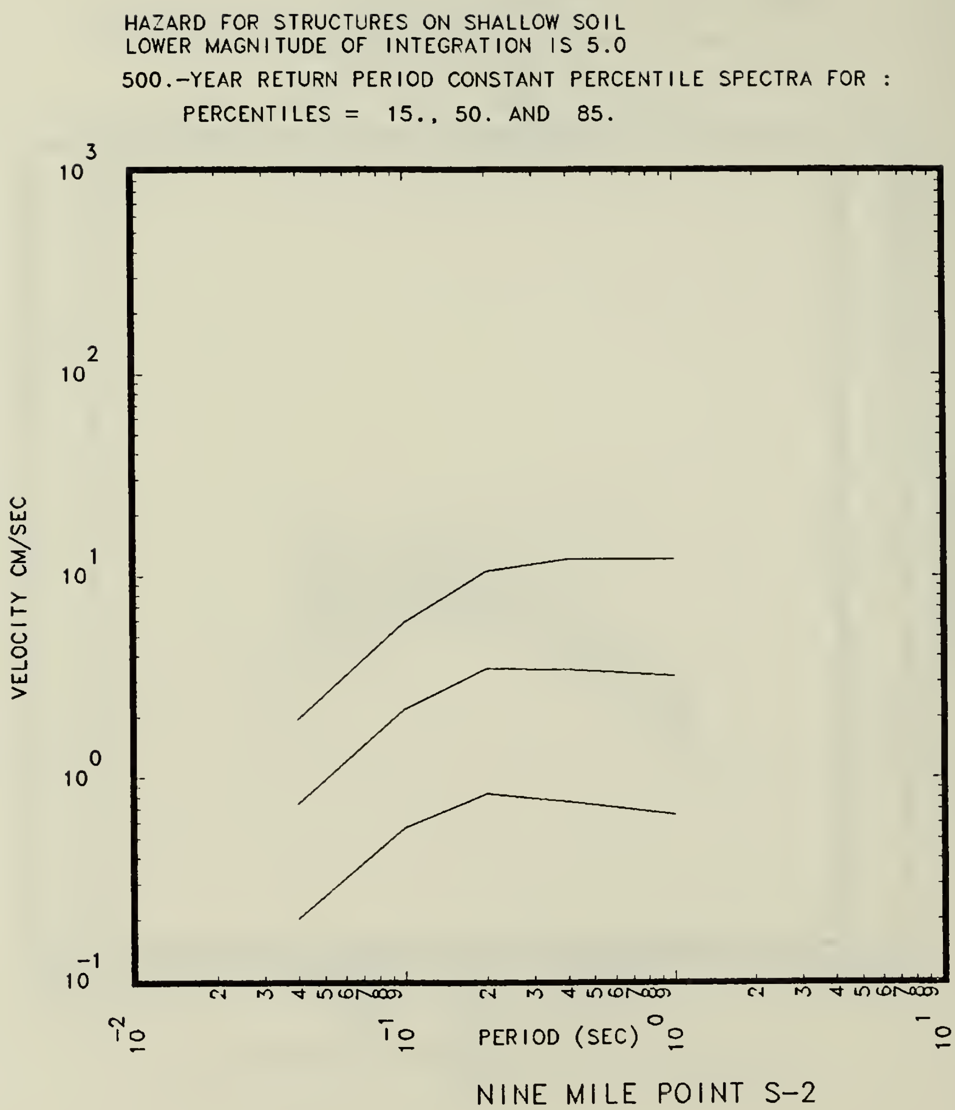


Figure 2.1.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Nine Mile Point site.

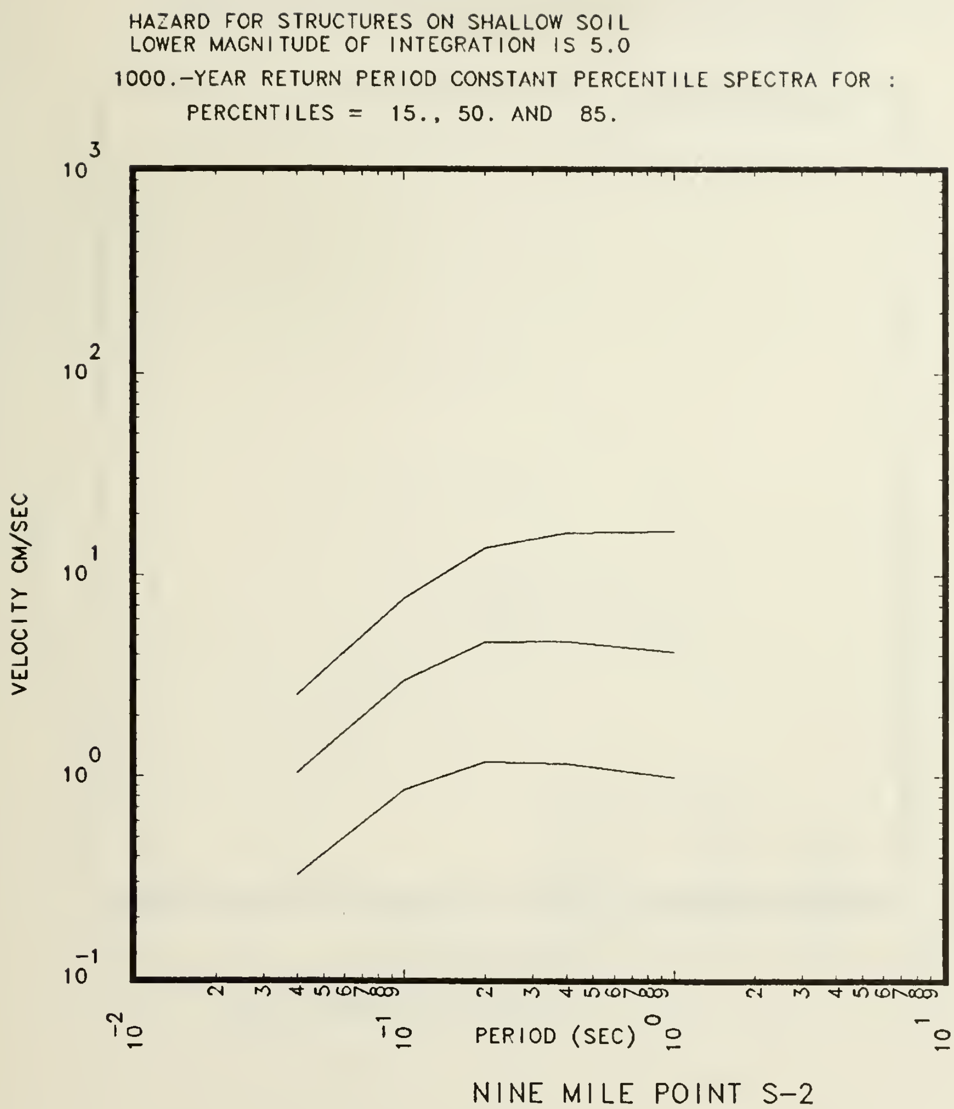


Figure 2.1.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Nine Mile Point site.

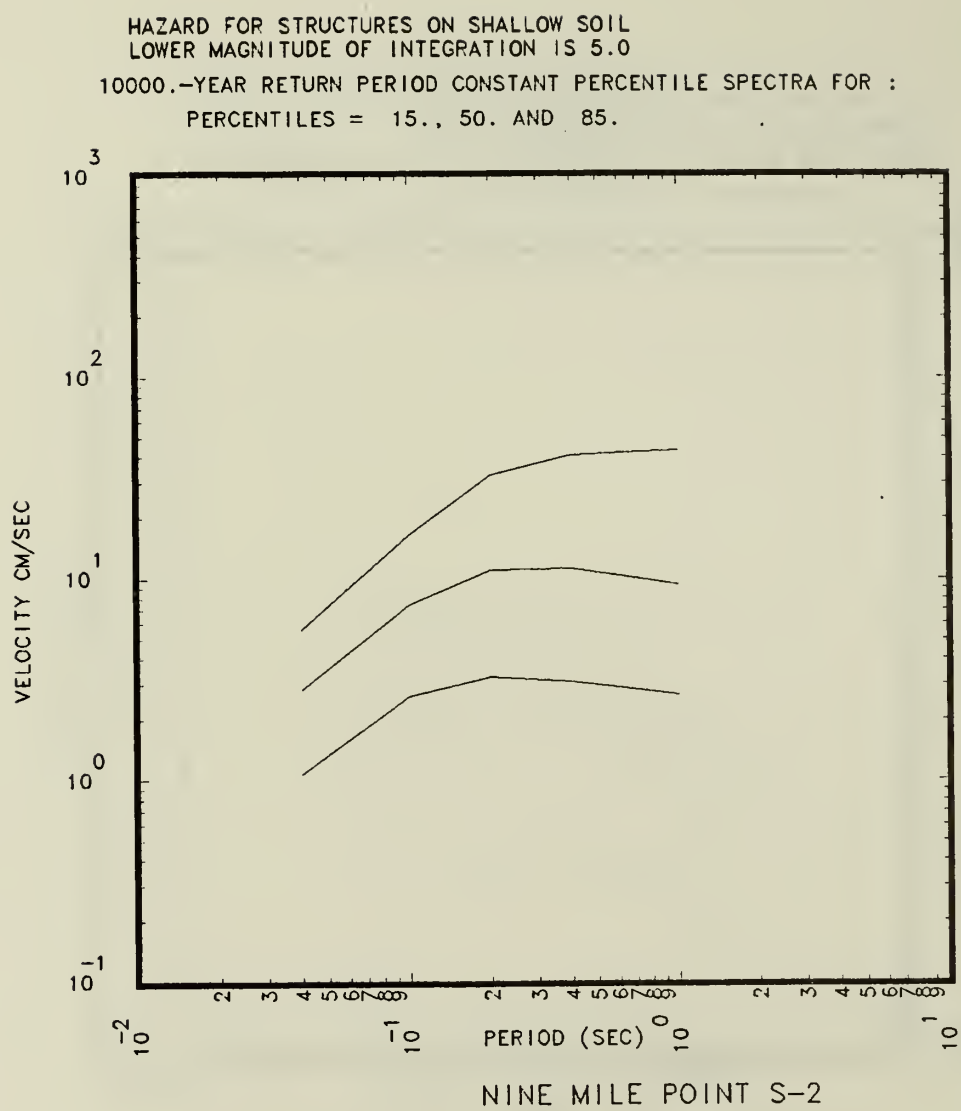


Figure 2.1.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Nine Mile Point site.

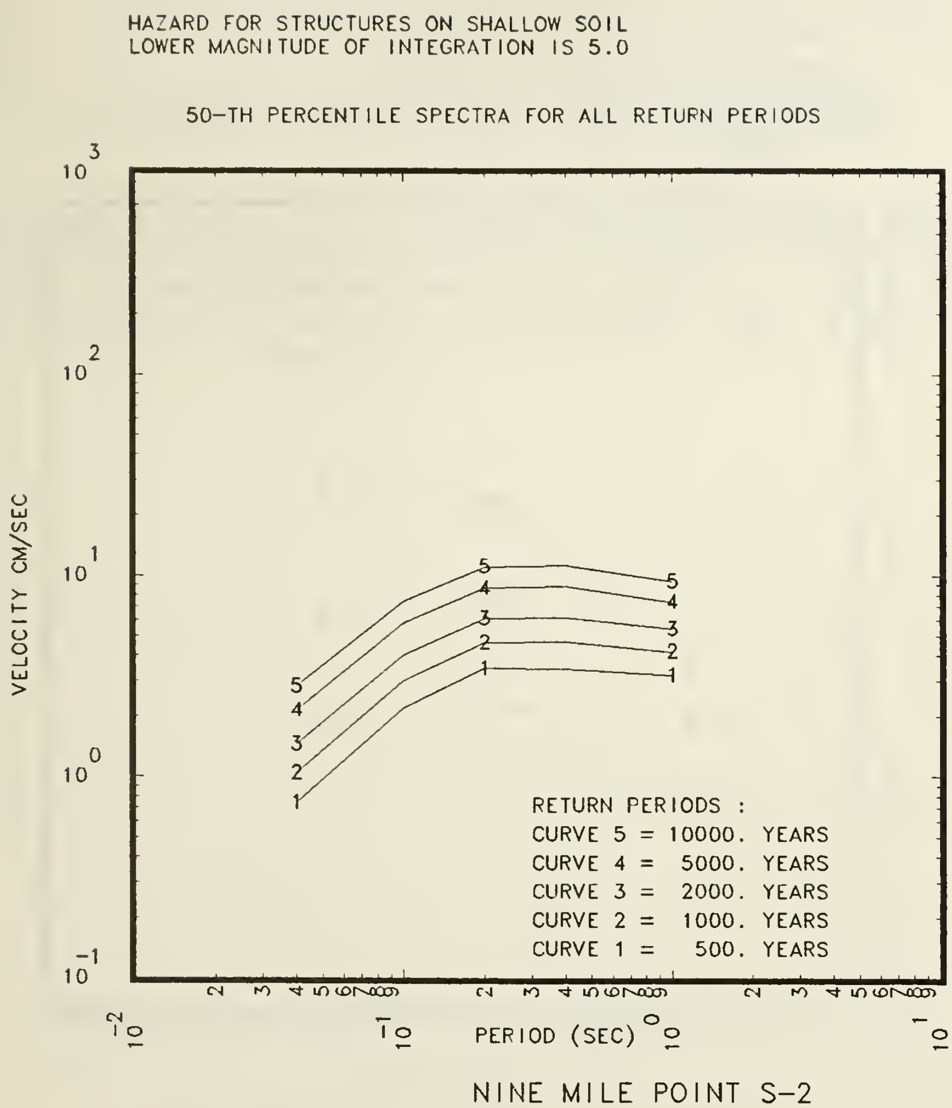


Figure 2.1.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Nine Mile Point site.

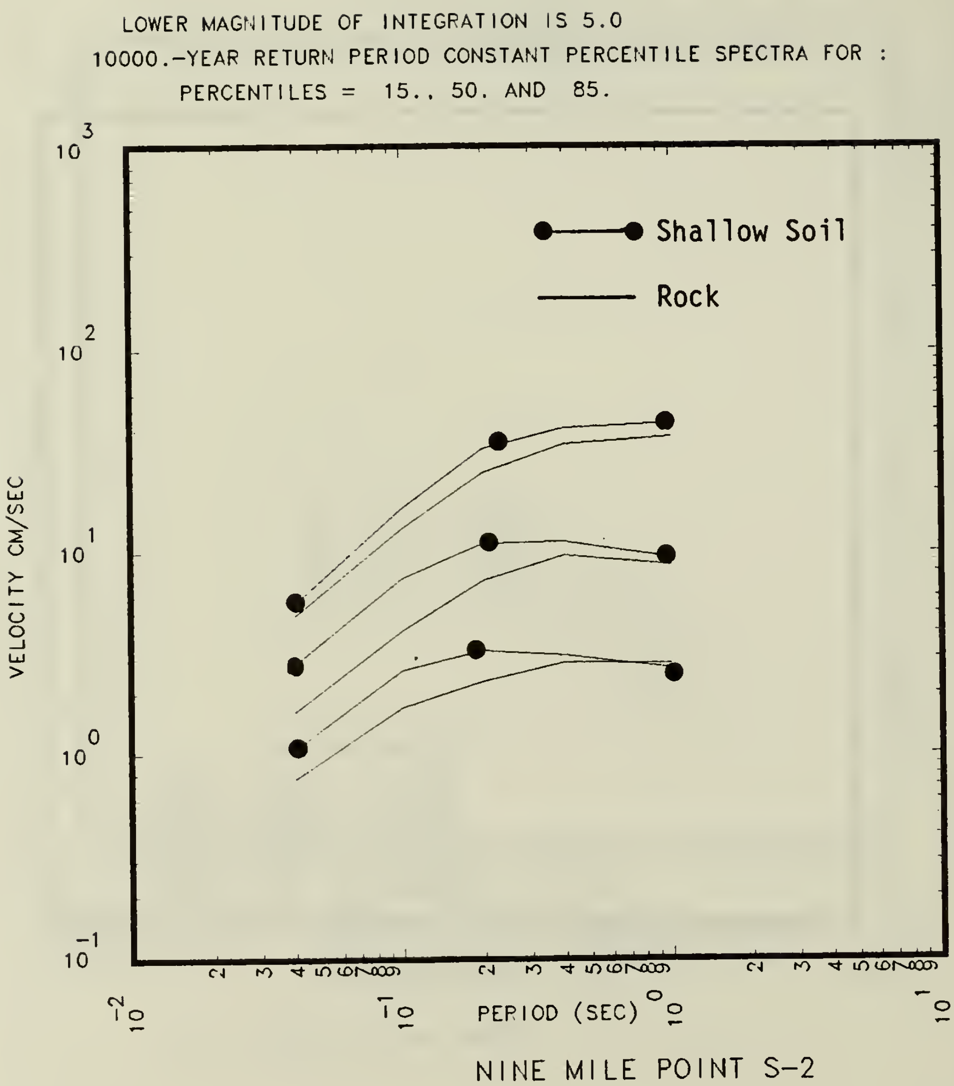


Figure 2.1.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Nine Mile Point site.

2.2 Susquehanna

The location of the Susquehanna site is shown in Fig. 1.1 by the plot symbol "2". Most of the structures at the Susquehanna site are founded on rock. The hazard results for the rock case are given in Section 2.16 of Vol. II. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Susquehanna site was considered to be best represented by our Till-2 soil category described in Section 3.7 of Vol. I. Table 2.2.1 and Figs. 2.2.1 to 2.2.11 give the basic results most applicable to the structures founded on shallow soil at the Susquehanna site.

In Section 2.16 of Vol. II we noted that the zones near the site contributed most to the BEHC for PGA, thus as expected we do not see major changes between Table 2.16.1 in Vol. II and Table 2.2.1 in this section. Additionally, the differences in the CPHCs (Fig. 2.2.4) and the CPUHS (Fig. 2.2.11) between the rock and Till-2 cases are similar to the differences found in Section 2.2 of Vol. VI.

TABLE 2.2.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SUSQUEHANNA S-2

SITE SOIL CATEGORY TILL-2

S-XPT NUM.	HOST ZONE		Low PGA (0.125G)				High PGA (0.60G)			
			ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 4	ZONE ID:	ZONE 4	ZONE 20	ZONE 21	ZONE 19	ZONE 4	ZONE 20	ZONE 21	ZONE 1
		% CONT.:	89.	7.	2.	1.	99.	1.	0.	0.
2	COMP. ZO	ZONE ID:	ZONE 28	ZONE 32	COMP. ZON	ZONE 31	COMP. ZON	ZONE 28	ZONE 32	ZONE 31
		% CONT.:	65.	15.	12.	7.	50.	39.	9.	2.
3	ZONE 5	ZONE ID:	ZONE 5	ZONE 4	ZONE 2	ZONE 11	ZONE 5	COMP. ZON	ZONE 2	ZONE 4
		% CONT.:	95.	1.	1.	1.	100.	0.	0.	0.
4	ZONE 12	ZONE ID:	ZONE 12	ZONE 16	ZONE 11	ZONE 8	ZONE 12	ZONE 11	ZONE 16	ZONE 8
		% CONT.:	85.	7.	4.	1.	100.	0.	0.	0.
5	COMP. ZO	ZONE ID:	ZONE 6	ZONE 1	COMP. ZON	ZONE 3	ZONE 1	COMP. ZON	ZONE 3	ZONE 5
		% CONT.:	79.	14.	2.	2.	79.	20.	1.	0.
6	COMP. ZO	ZONE ID:	ZONE 6	ZONE 7	COMP. ZON	ZONE 3	ZONE 6	COMP. ZON	ZONE 7	ZONE 3
		% CONT.:	64.	16.	9.	6.	67.	26.	6.	0.
7	ZONE 7	ZONE ID:	ZONE 7	ZONE 41	ZONE 17	ZONE 13	ZONE 7	ZONE 41	ZONE 2 =	ZONE 13
		% CONT.:	84.	6.	3.	2.	99.	1.	0.	0.
10	ZONE 5	ZONE ID:	ZONE 5	ZONE 19 =	ZONE 4B	ZONE 6	ZONE 5	ZONE 19 =	ZONE 4B	ZONE 1
		% CONT.:	86.	8.	2.	1.	91.	9.	0.	0.
11	ZONE 5	ZONE ID:	ZONE 5	CZ = ZONE	ZONE 3	ZONE 4	ZONE 5	CZ = ZONE	ZONE 4	ZONE 3
		% CONT.:	85.	6.	5.	4.	98.	1.	0.	0.
12	ZONE 27	ZONE ID:	ZONE 27	ZONE 32	ZONE 31	ZONE 34	ZONE 27	ZONE 32	ZONE 17	ZONE 18
		% CONT.:	72.	15.	9.	3.	98.	2.	0.	0.
13	CZ 15	ZONE ID:	CZ 15	ZONE 10	ZONE 12	ZONE 11	CZ 15	ZONE 10	ZONE 7	ZONE 8
		% CONT.:	80.	9.	6.	3.	100.	0.	0.	0.

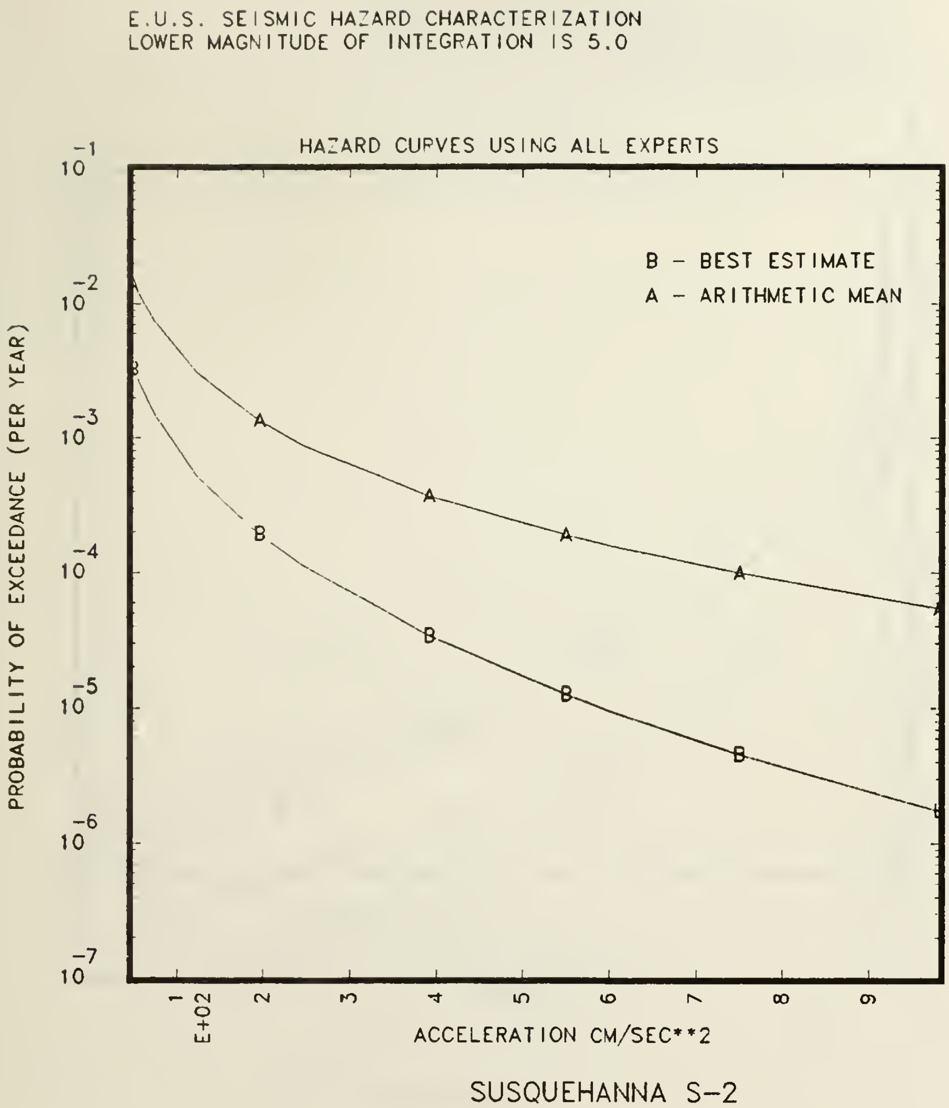


Figure 2.2.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Susquehanna site.

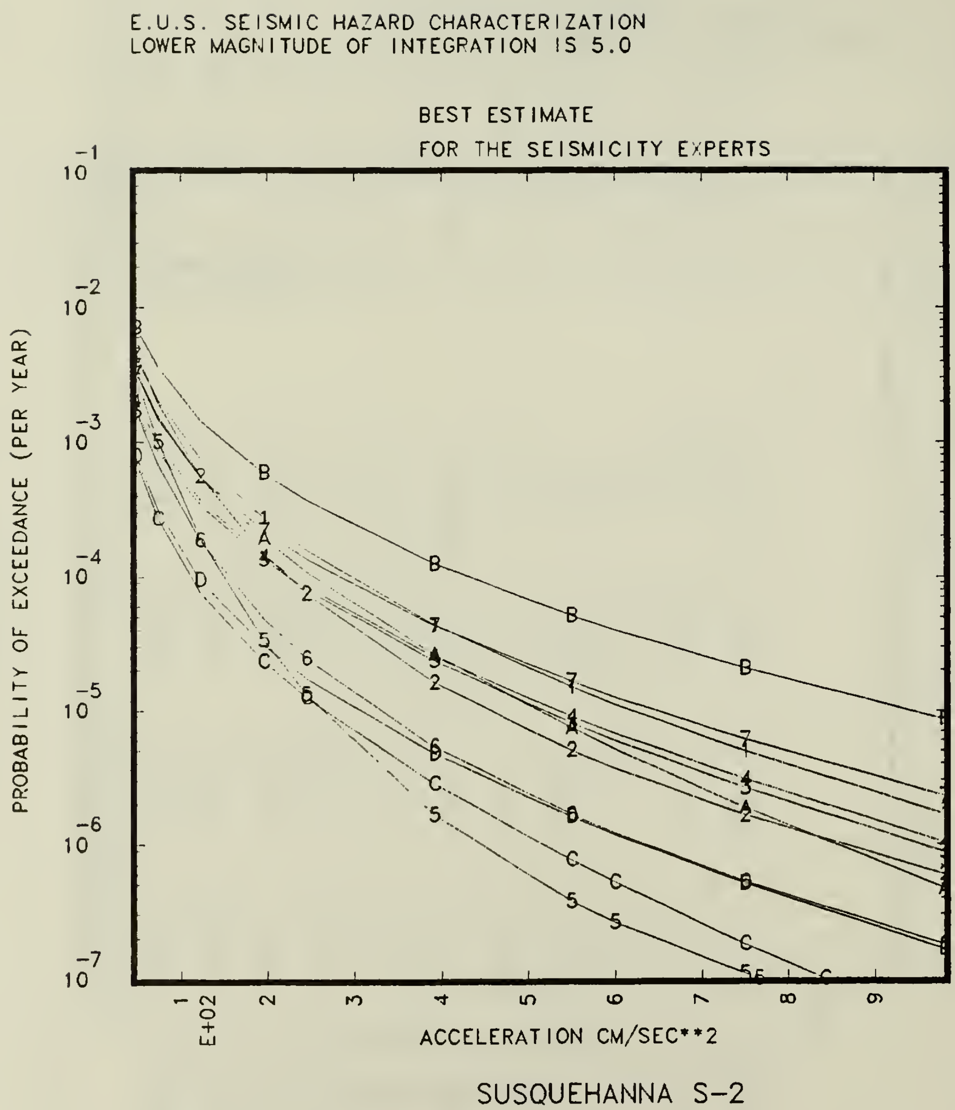


Figure 2.2.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Susquehanna site. Plot symbols given in Table 2.0.

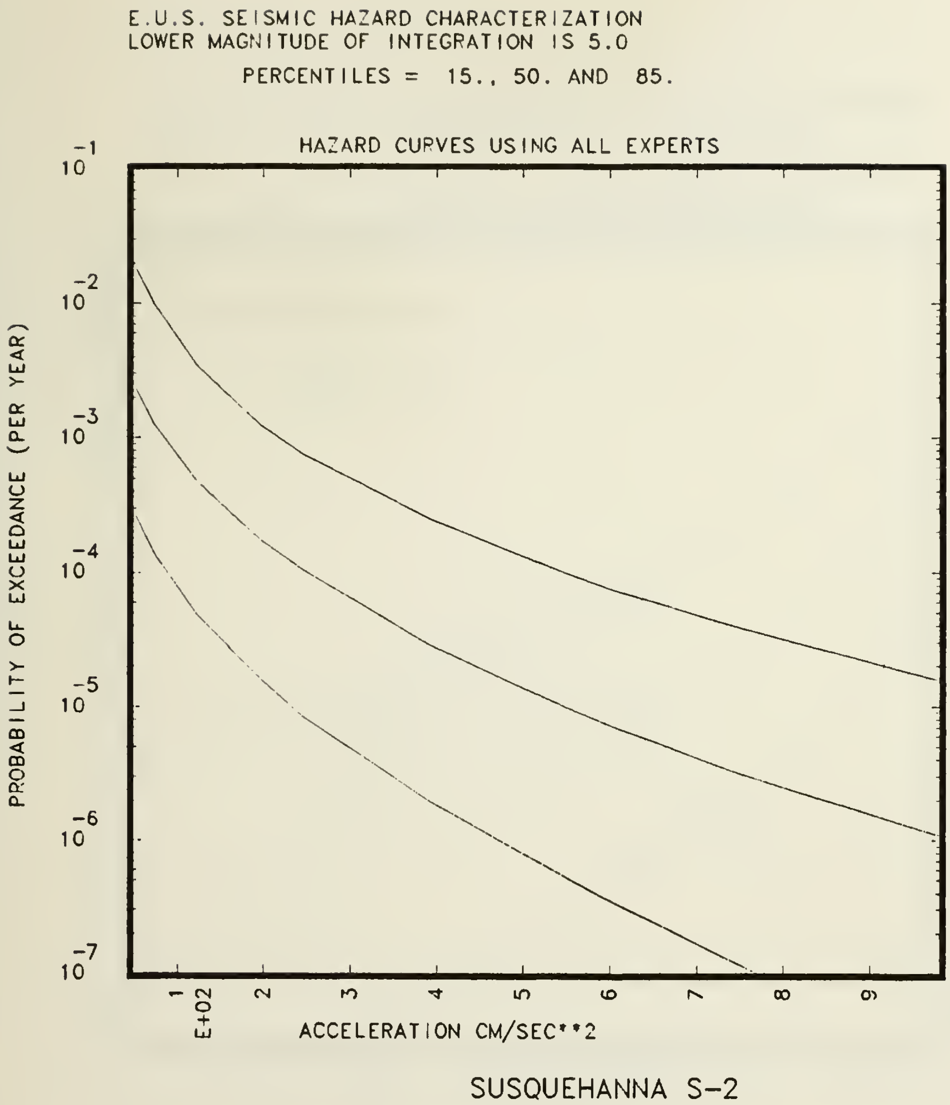


Figure 2.2.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Susquehanna site.

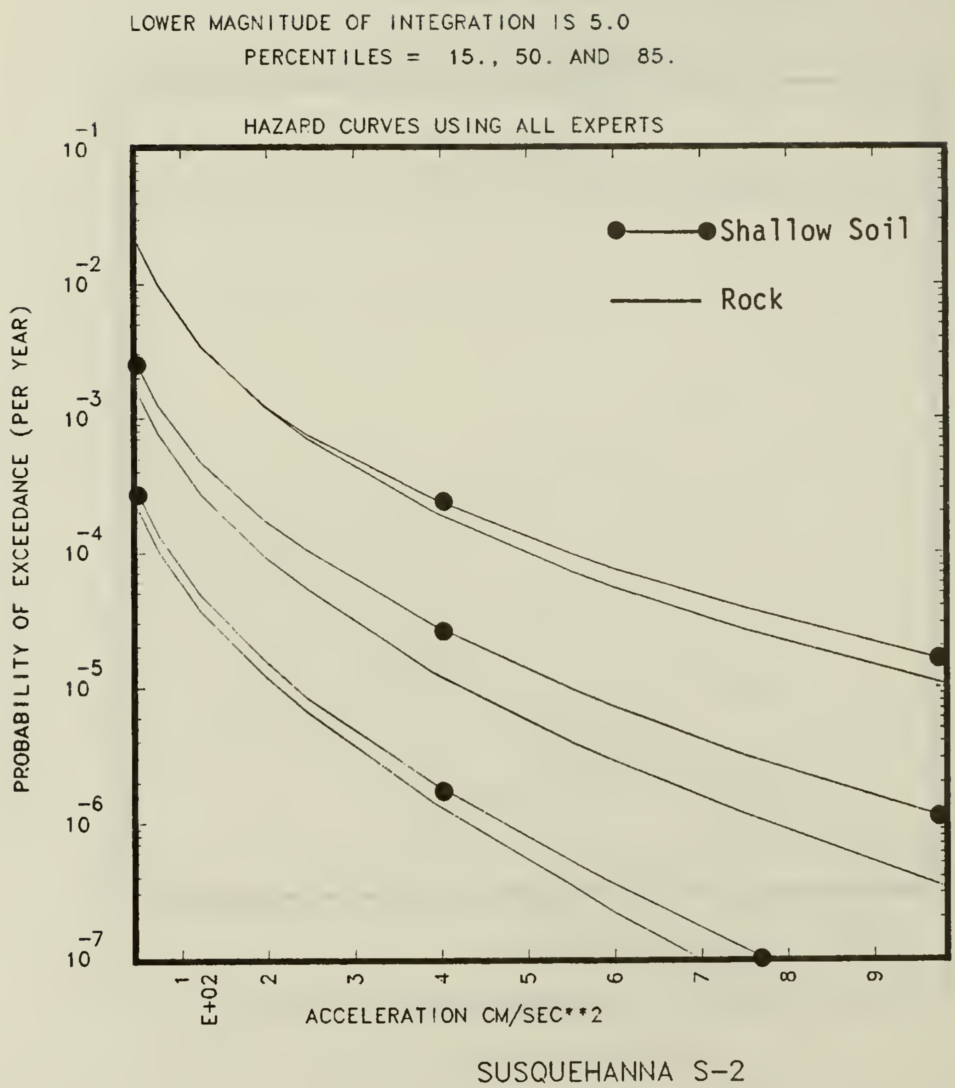


Figure 2.2.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Susquehanna site.

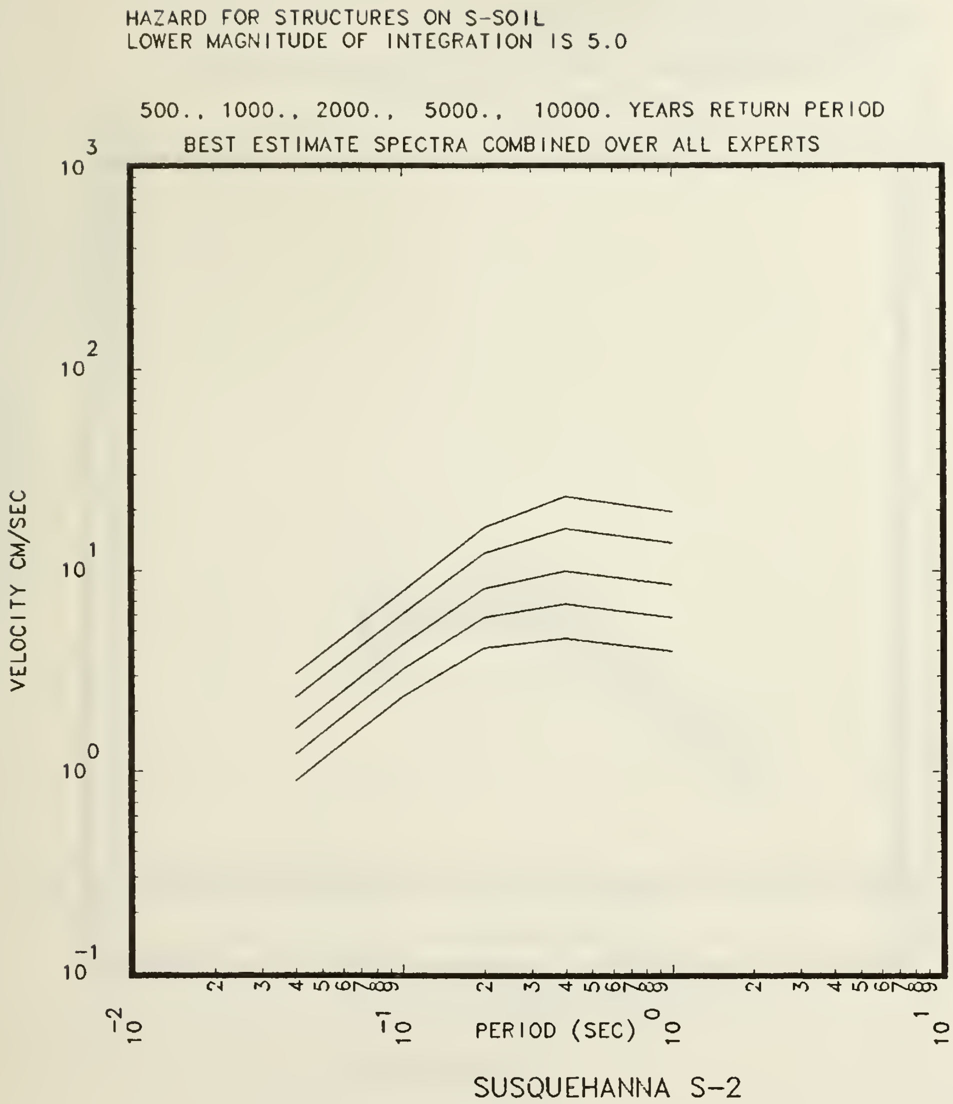


Figure 2.2.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Susquehanna site.

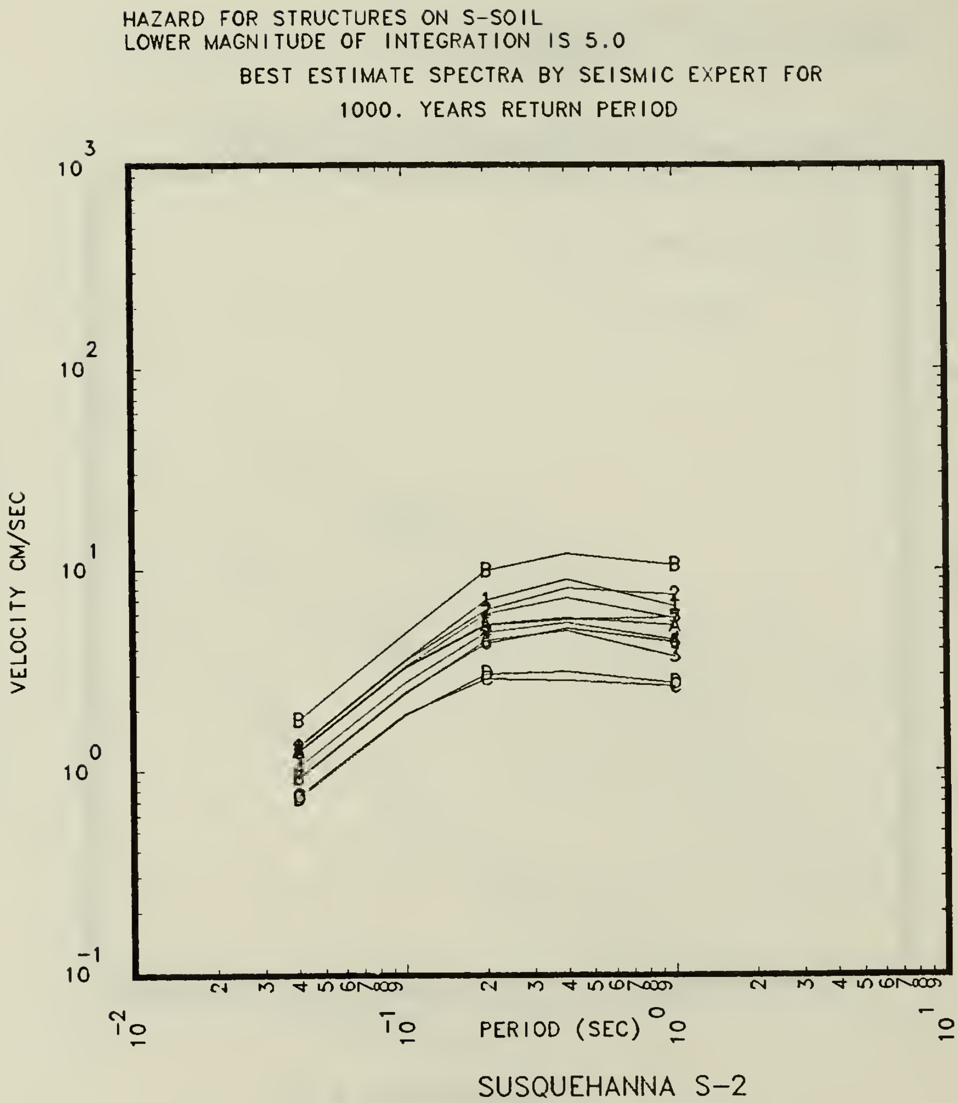


Figure 2.2.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Susquehanna site. Plot symbols are given in Table 2.0

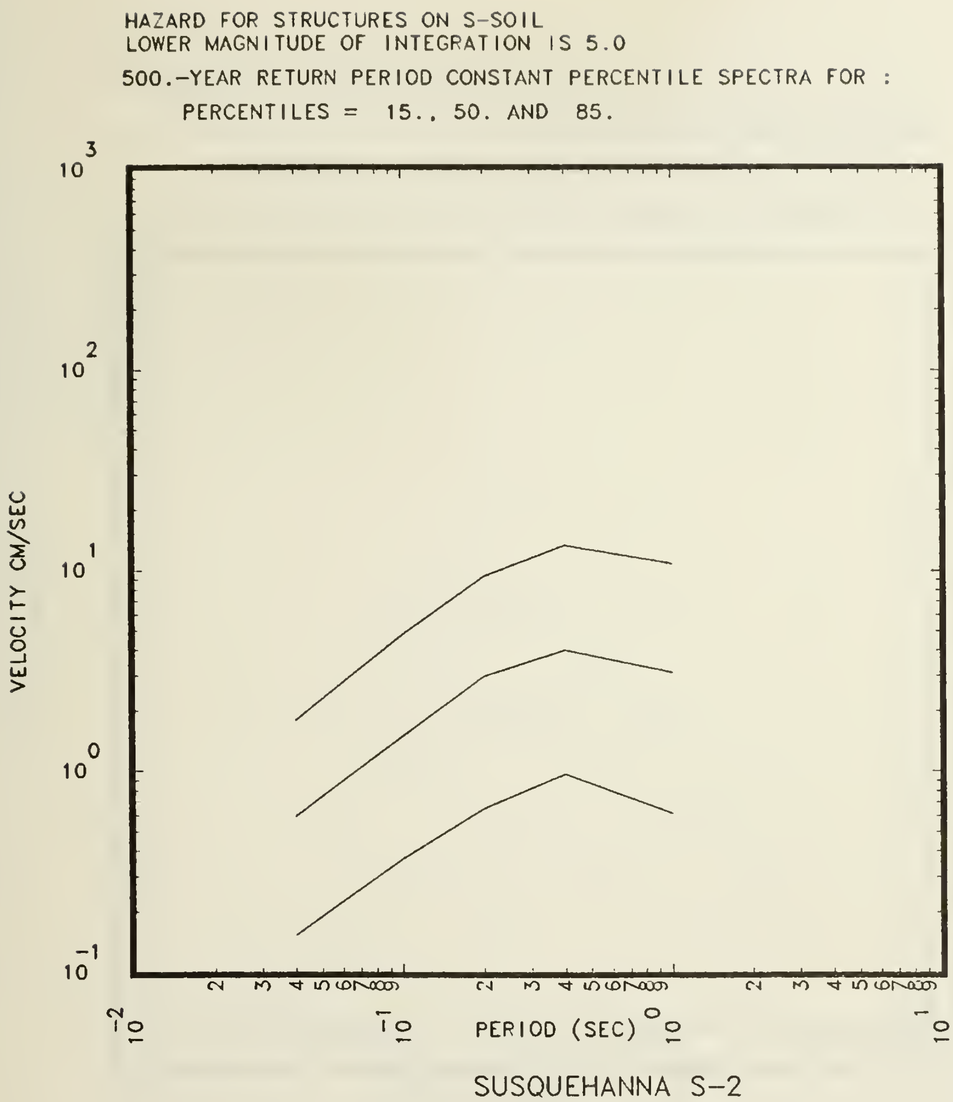


Figure 2.2.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Susquehanna site.

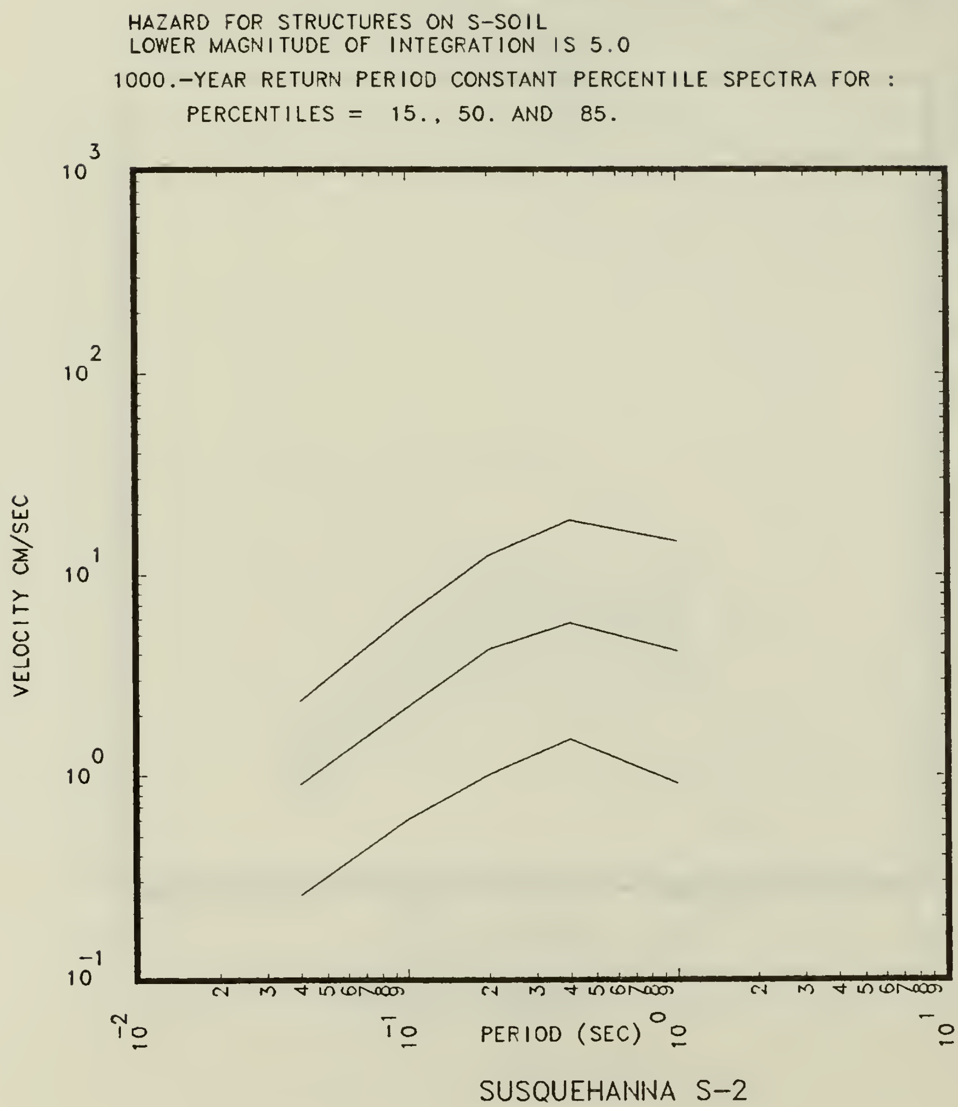


Figure 2.2.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Susquehanna site.

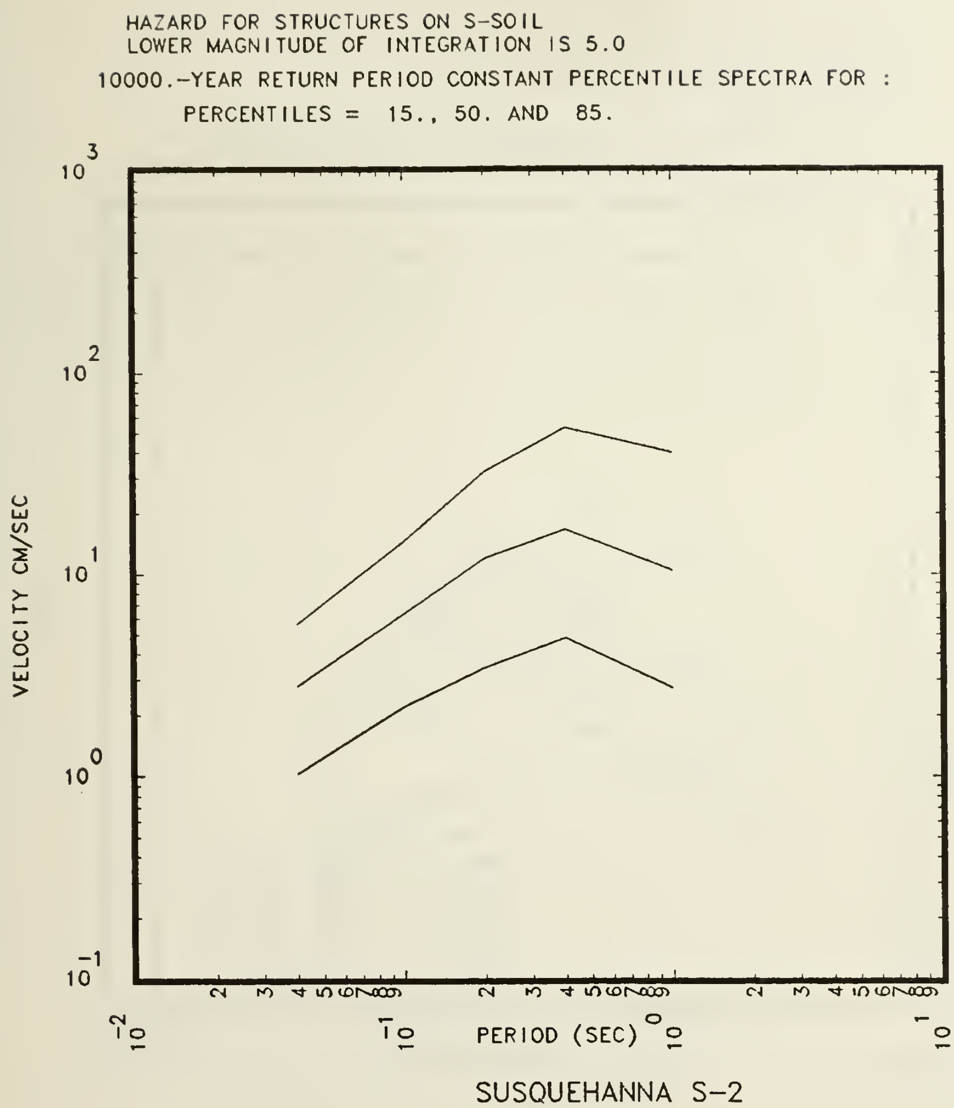


Figure 2.2.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Susquehanna site.

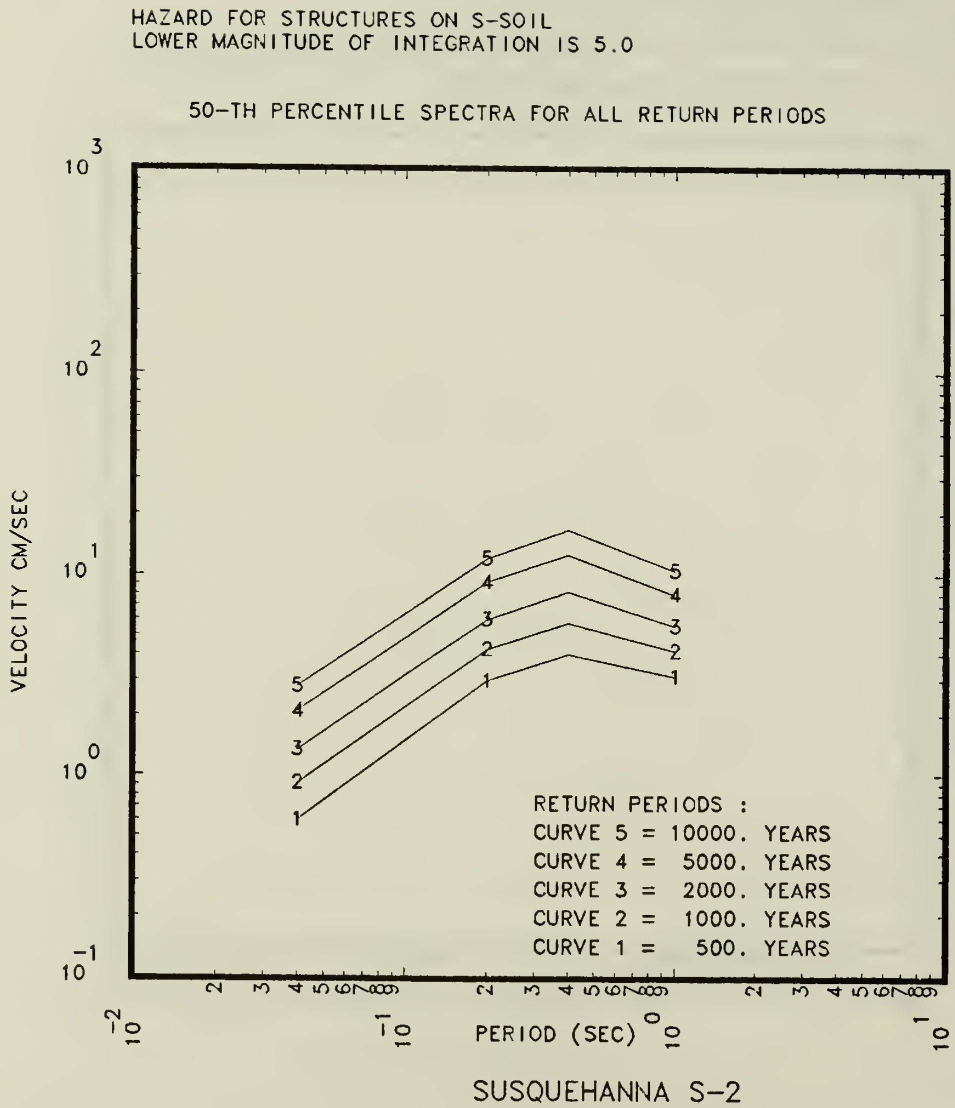


Figure 2.2.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Susquehanna site.

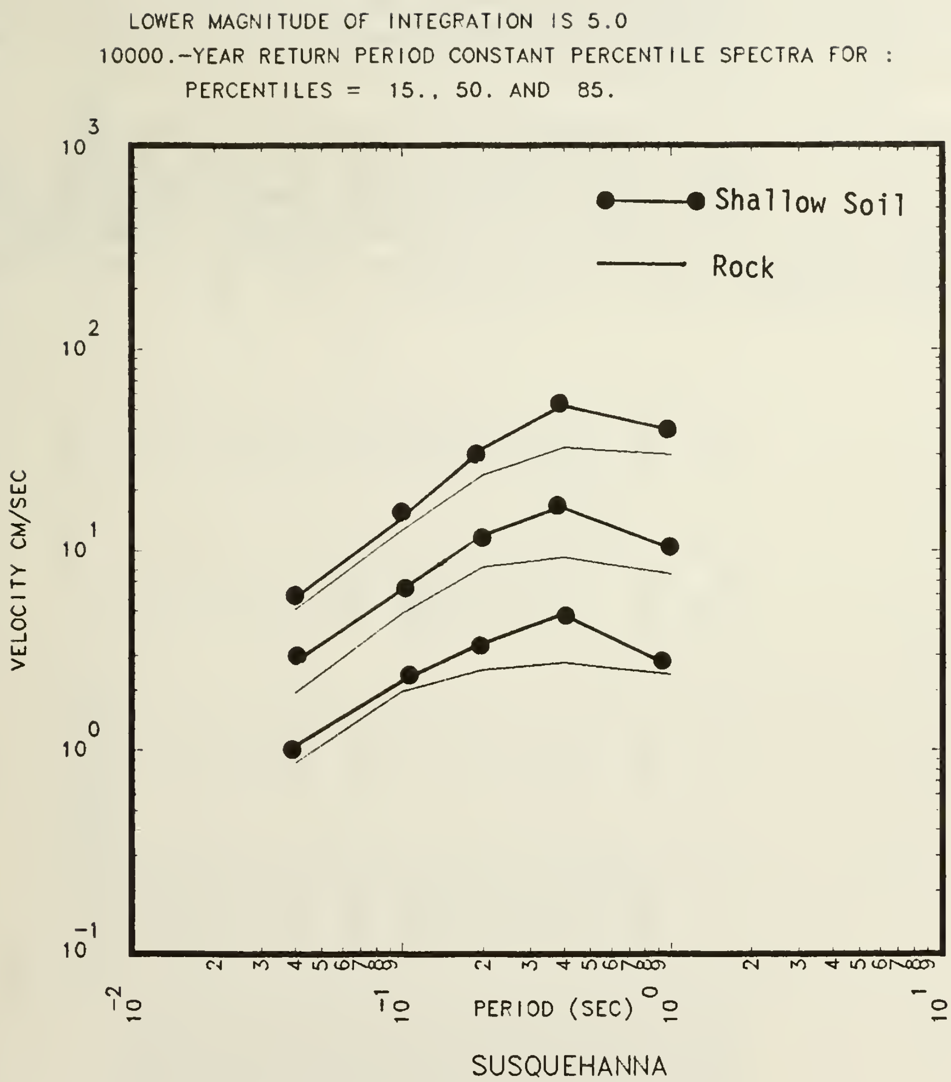


Figure 2.2.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Susquehanna site.

2.3 Three Mile Island

The location of the Three Mile Island site is shown in Fig. 1.1 by the plot symbol "3". Most of the structures at the Three Mile Island site are founded on rock. The hazard results for the rock case are given in Section 2.17 of Vol. II. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Three Mile Island site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.3.1 and Figs. 2.3.1 to 2.3.11 give the basic results most applicable to the structures founded on shallow soil at the Three Mile Island site.

As can be seen from Fig. 1.1 the Three Mile Island site is near the Susquehanna site and similarly the hazard for both the rock case is primarily from nearby zones. Thus there are only relatively minor differences between Table 2.3.1 and Table 2.17.1 of Vol. II. The differences in the CPHCs (Fig. 2.3.4) and the CPUHS (Fig. 2.3.11) between the rock and Sand-1 cases are similar to the differences found in Section 2.2 of Vol. VI.

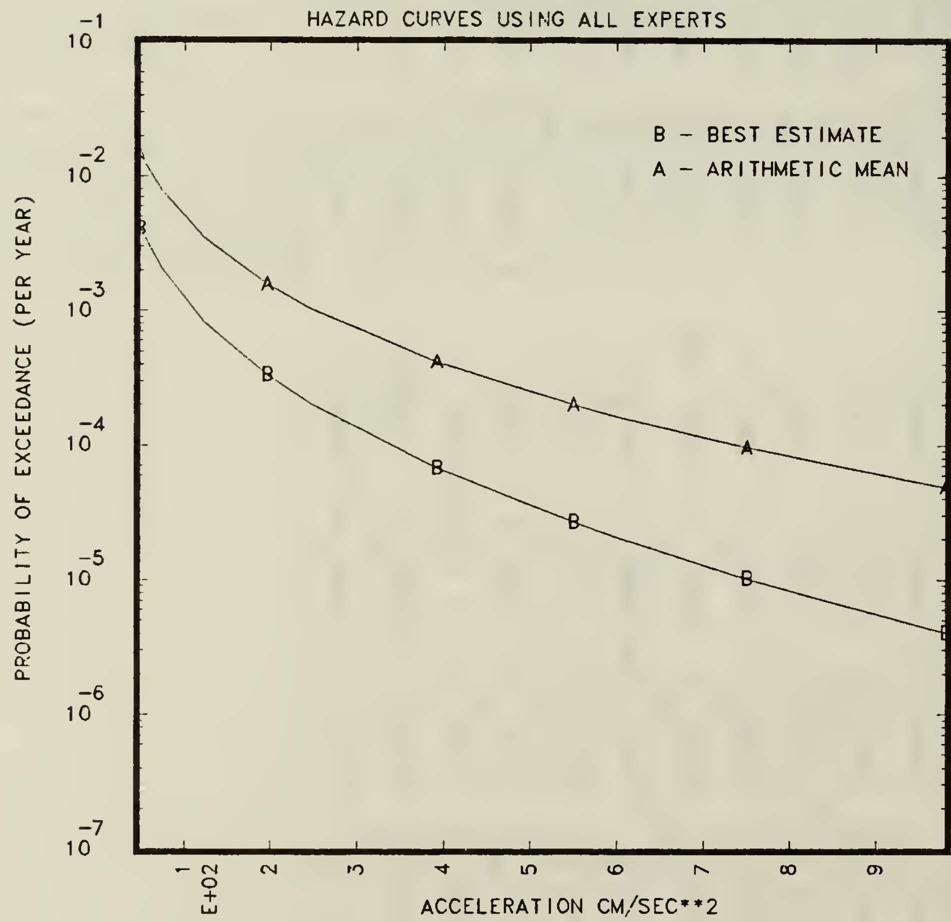
TABLE 2.3.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR THREE MILE ISLAND S-

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 4	ZONE ID:	ZONE 4	ZONE 20	ZONE 1	ZONE 21	ZONE 4	ZONE 1	ZONE 20	ZONE 3
		% CONT.:	94.	2.	1.	1.	100.	0.	0.	0.
2	ZONE 28	ZONE ID:	ZONE 28	ZONE 30	ZONE 32	ZONE 27	ZONE 28	COMP. ZON	ZONE 32	ZONE 27
		% CONT.:	92.	2.	2.	1.	99.	0.	0.	0.
3	ZONE 5	ZONE ID:	ZONE 5	ZONE 8A	ZONE 4	ZONE 11	ZONE 5	COMP. ZON	ZONE 8A	ZONE 3
		% CONT.:	98.	1.	0.	0.	100.	0.	0.	0.
4	ZONE 11	ZONE ID:	ZONE 11	ZONE 12	ZONE 8	ZONE 16	ZONE 11	ZONE 12	ZONE 8	COMP. ZON
		% CONT.:	46.	40.	7.	4.	85.	13.	2.	0.
5	ZONE 1	ZONE ID:	ZONE 1	ZONE 6	ZONE 9	COMP. ZON	ZONE 1	COMP. ZON	ZONE 9	ZONE 3
		% CONT.:	63.	30.	5.	1.	100.	0.	0.	0.
6	COMP. ZO	ZONE ID:	ZONE 6	COMP. ZON	ZONE 7	ZONE 15	ZONE 6	COMP. ZON	ZONE 7	ZONE 15
		% CONT.:	86.	4.	3.	2.	91.	9.	0.	0.
7	ZONE 7	ZONE ID:	ZONE 7	ZONE 29	ZONE 17	ZONE 13	ZONE 7	ZONE 29	ZONE 2 =	ZONE 41
		% CONT.:	95.	2.	1.	1.	100.	0.	0.	0.
10	ZONE 4B	ZONE ID:	ZONE 5	ZONE 4B	ZONE 19 =	ZONE 6	ZONE 4B	ZONE 5	ZONE 19 =	ZONE 1
		% CONT.:	60.	36.	2.	0.	74.	21.	4.	0.
11	ZONE 5	ZONE ID:	ZONE 5	ZONE 3	CZ = ZONE	ZONE 4	ZONE 5	CZ = ZONE	ZONE 8	ZONE 3
		% CONT.:	95.	2.	1.	1.	100.	0.	0.	0.
12	ZONE 27	ZONE ID:	ZONE 32	ZONE 27	ZONE 31	ZONE 23A	ZONE 32	ZONE 27	ZONE 17	ZONE 18
		% CONT.:	76.	21.	2.	0.	87.	13.	0.	0.
13	CZ 15	ZONE ID:	CZ 15	CZ 17	ZONE 10	ZONE 11	CZ 15	CZ 17	ZONE 10	ZONE 6
		% CONT.:	91.	4.	3.	1.	100.	0.	0.	0.

HAZARD FOR STRUCTURES ON SHALLOW SOIL
LOWER MAGNITUDE OF INTEGRATION IS 5.0



THREE MILE ISLAND S-2

Figure 2.3.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Three Mile Island site.

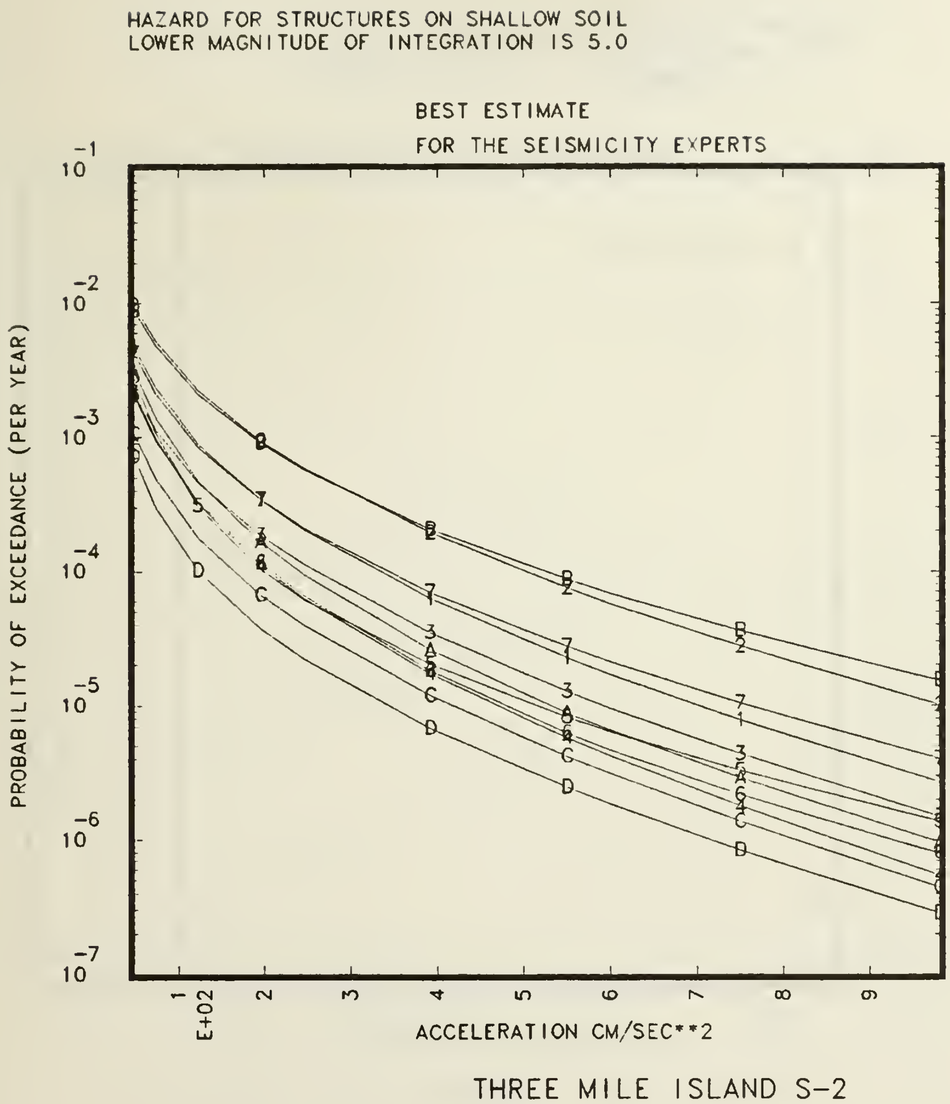


Figure 2.3.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Three Mile Island site. Plot symbols given in Table 2.0.

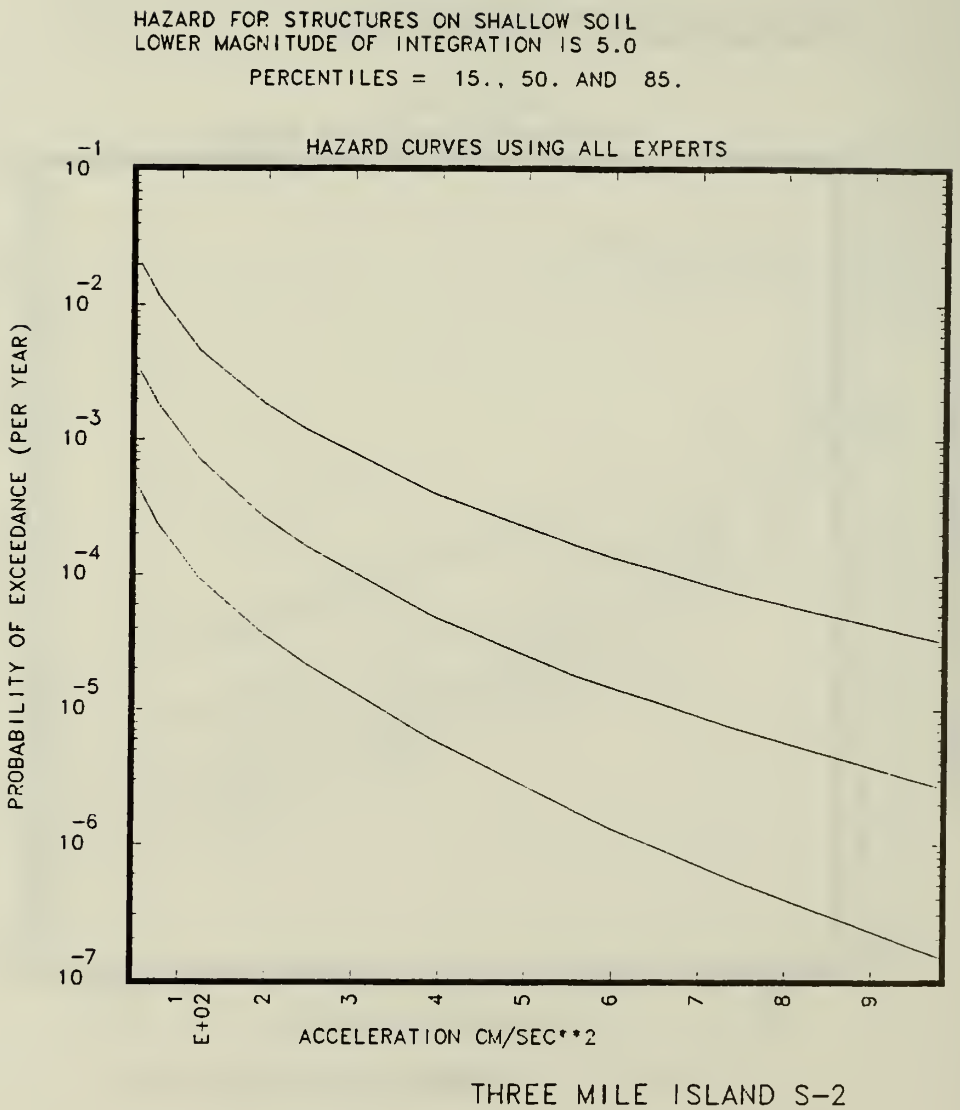


Figure 2.3.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Three Mile Island site.

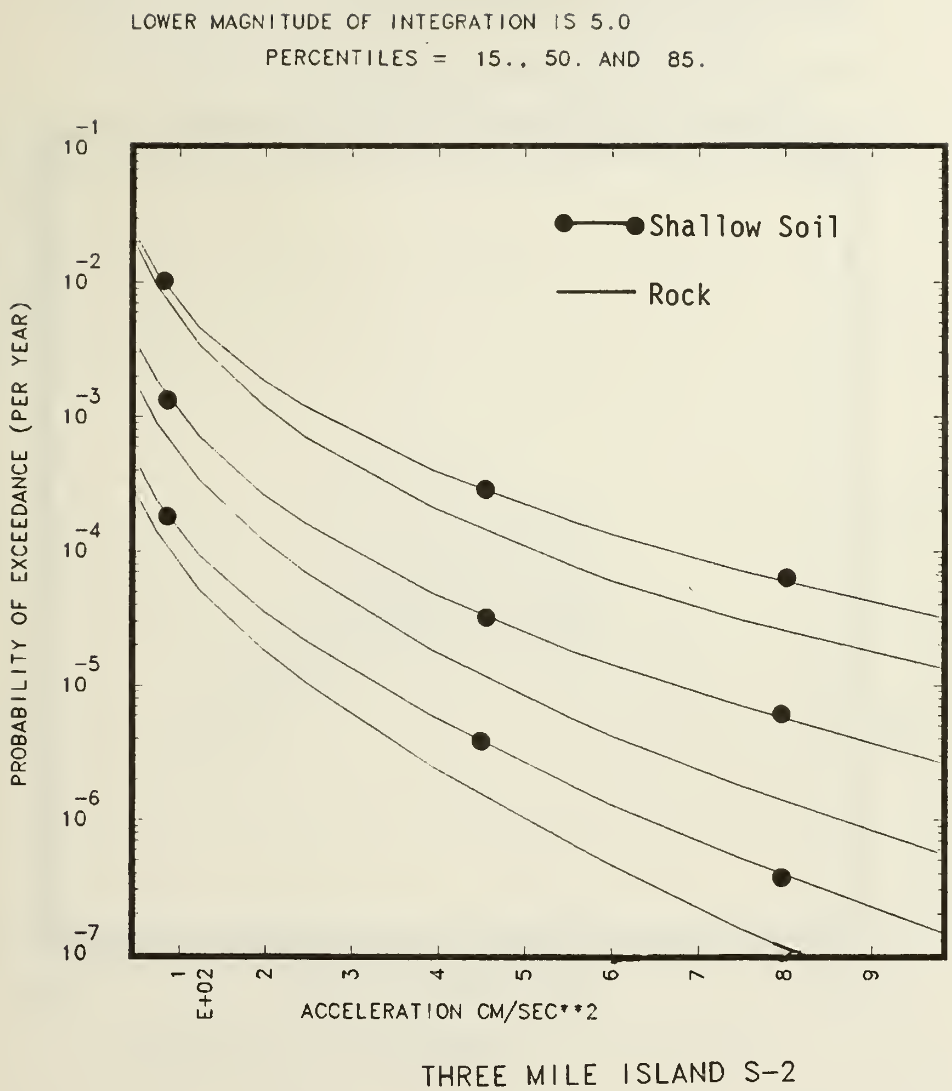


Figure 2.3.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Three Mile Island site.

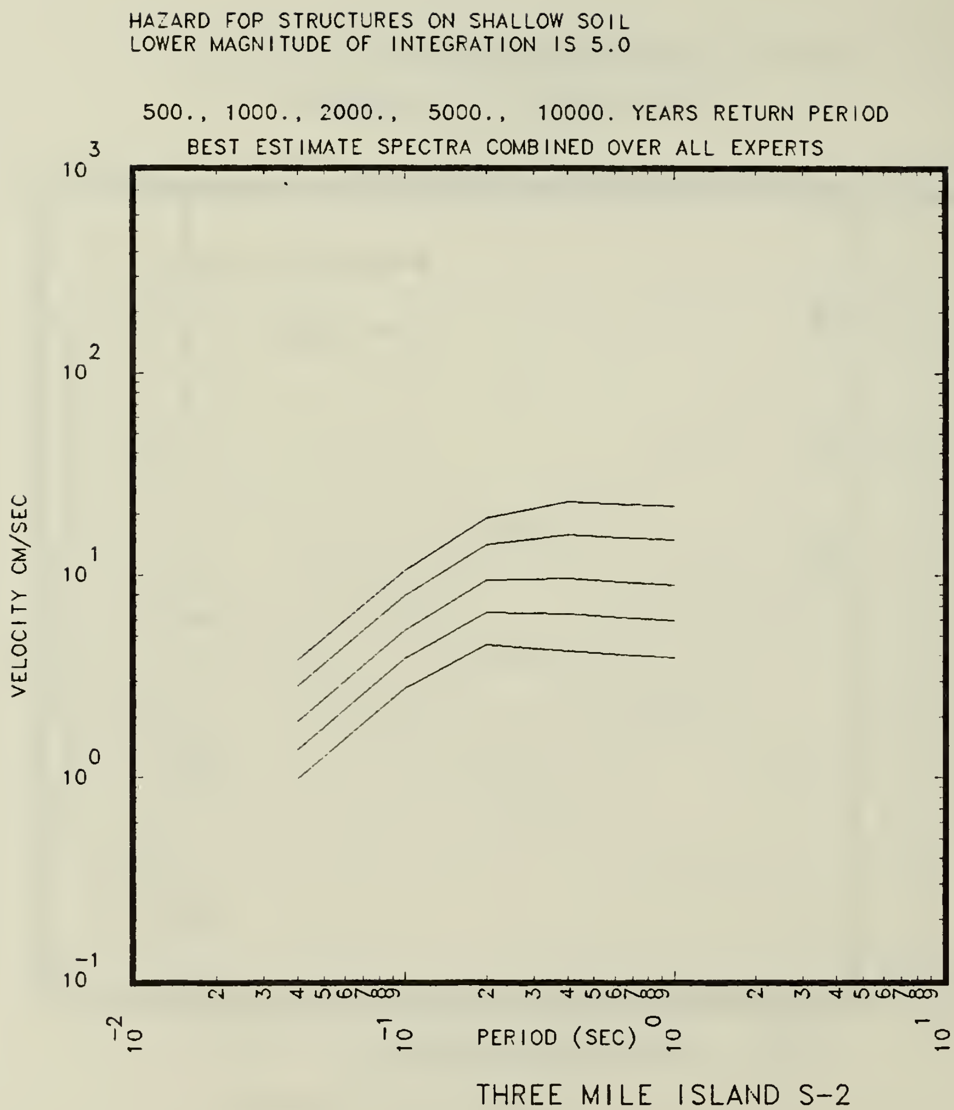


Figure 2.3.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Three Mile Island site.

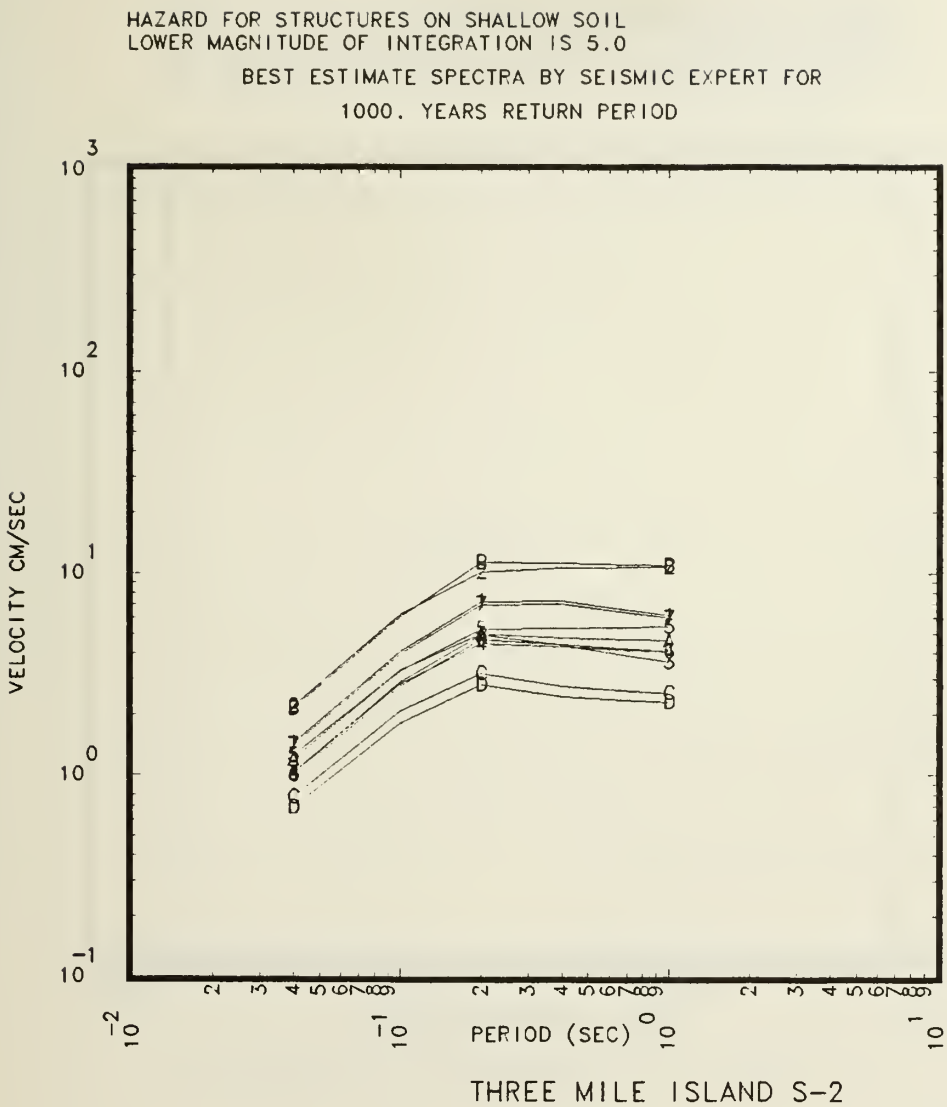


Figure 2.3.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Three Mile Island site. Plot symbols are given in Table 2.0

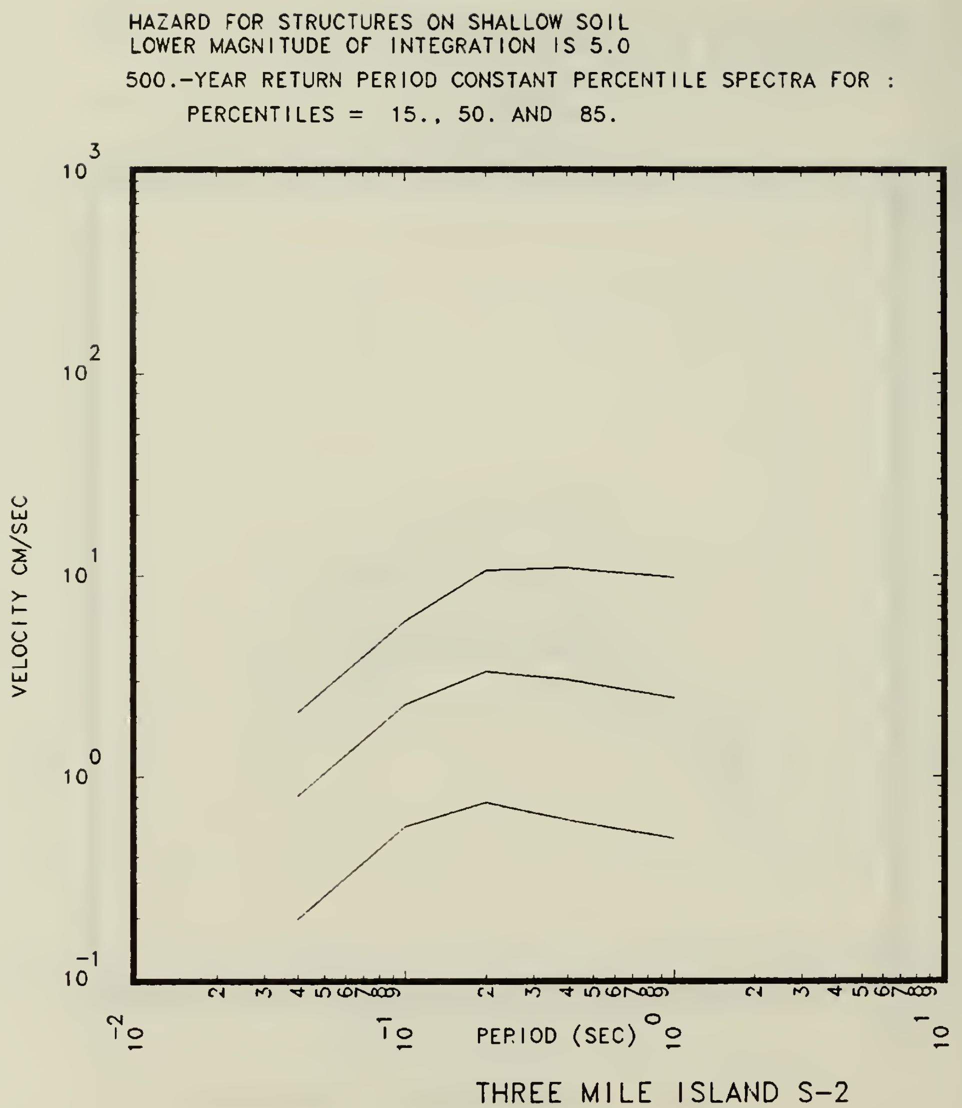


Figure 2.3.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Three Mile Island site.

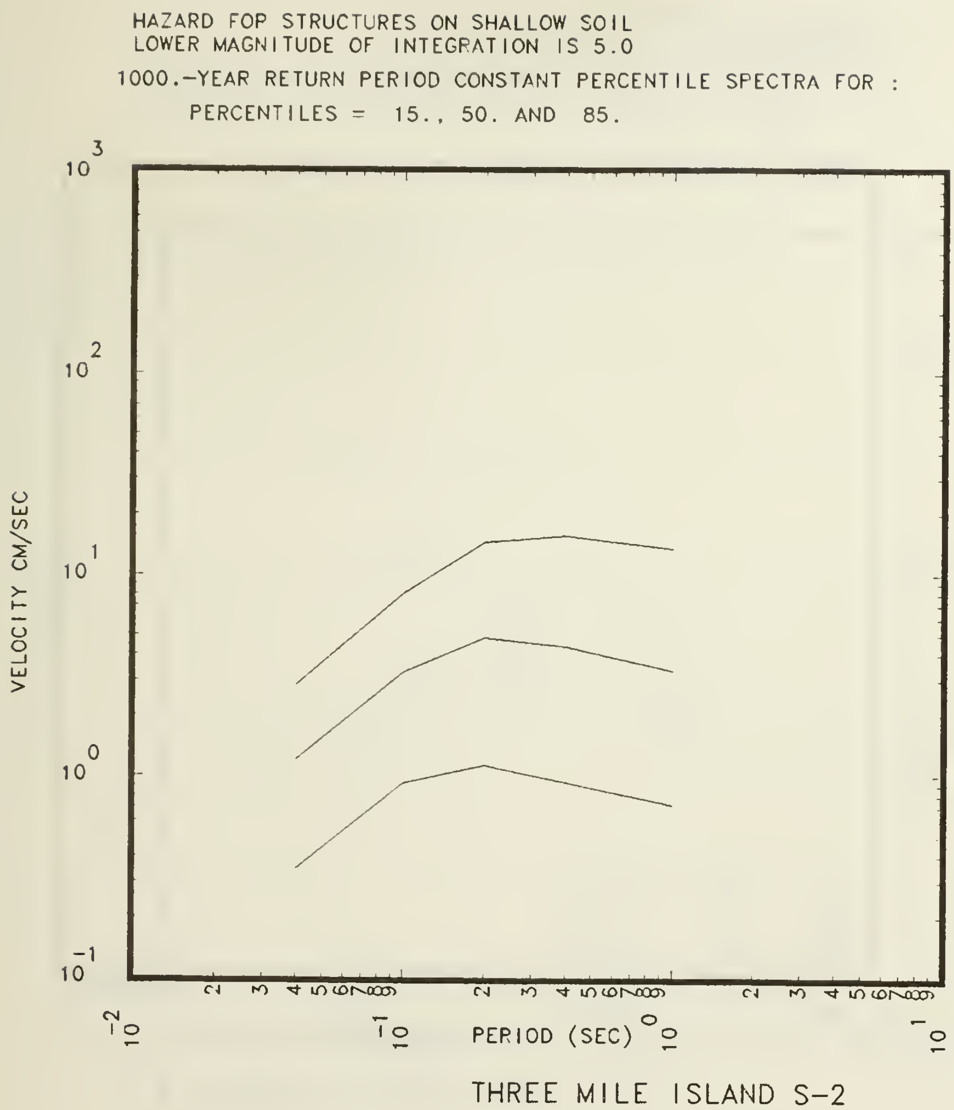


Figure 2.3.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Three Mile Island site.

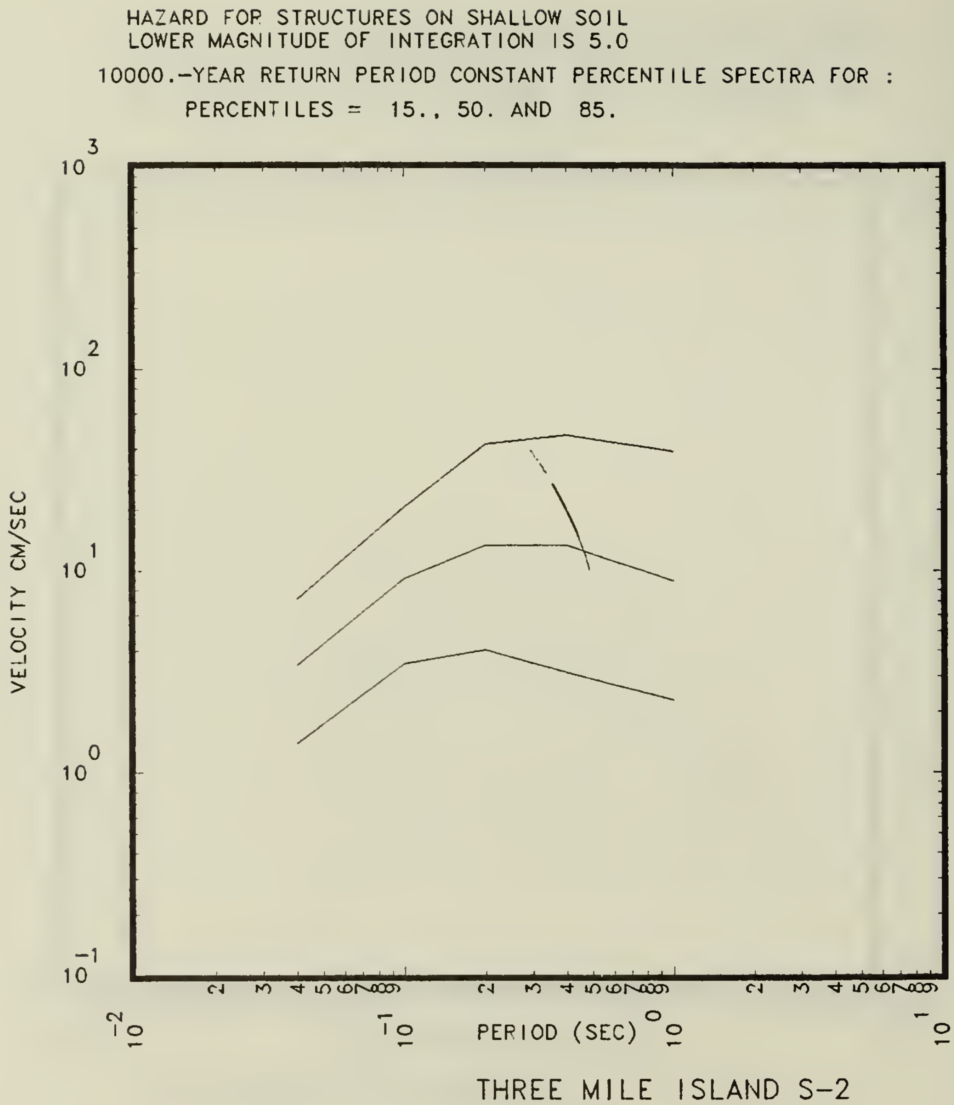


Figure 2.3.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Three Mile Island site.

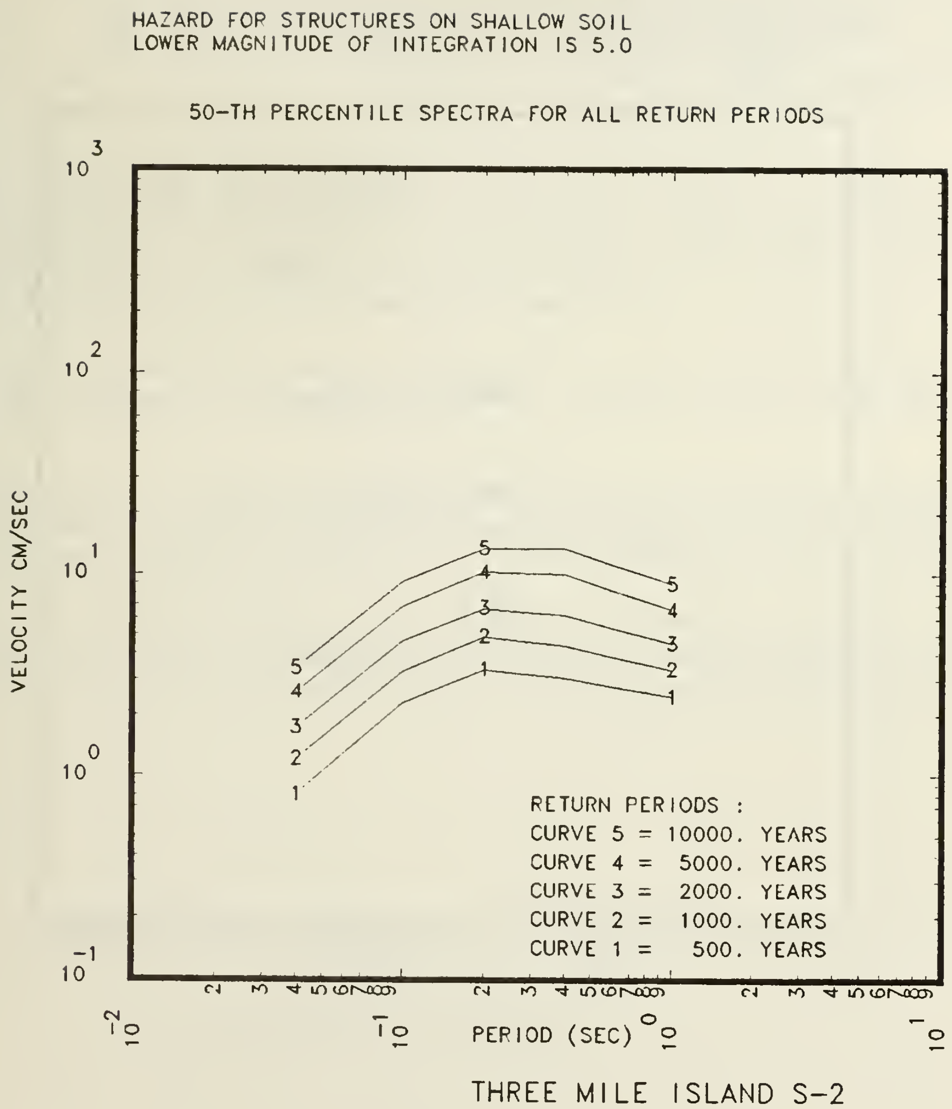


Figure 2.3.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Three Mile Island site.

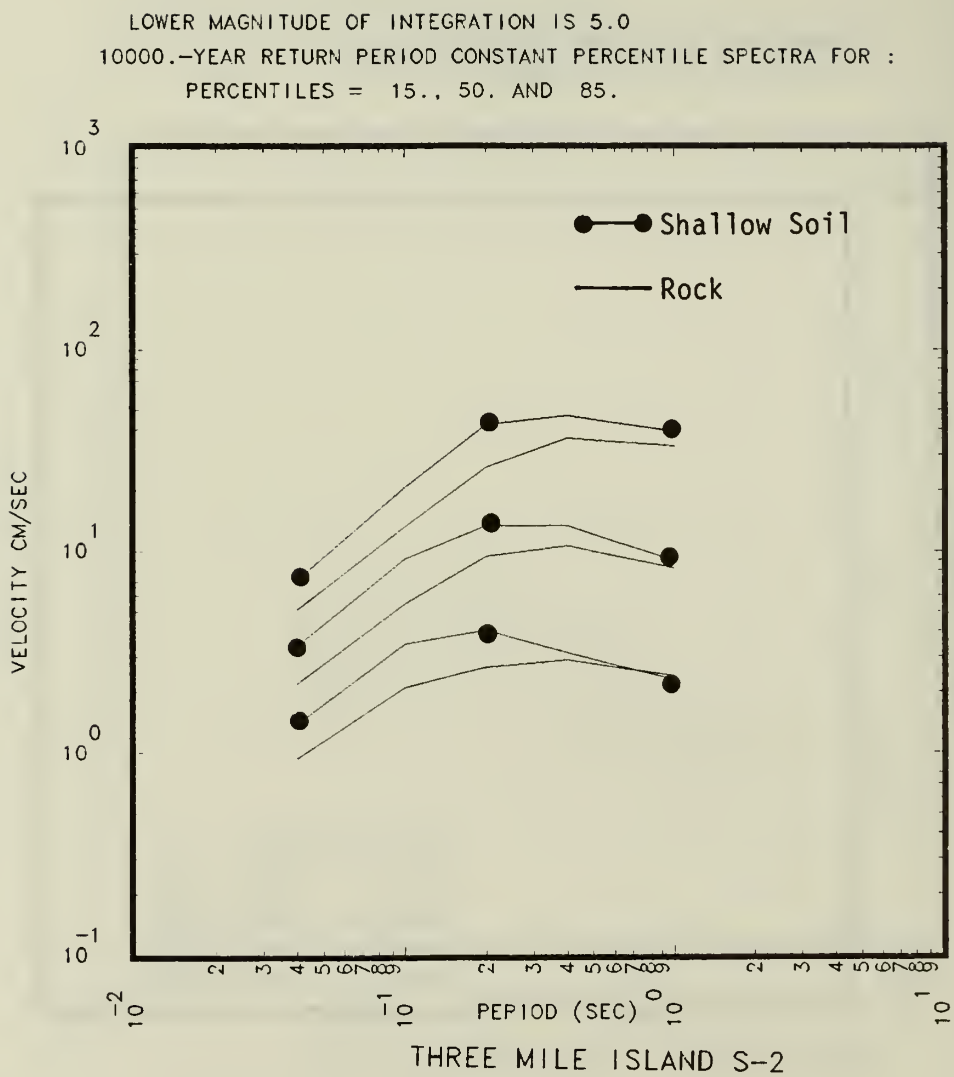


Figure 2.3.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Three Mile Island site.

2.4 Browns Ferry

The location of the Browns Ferry site is shown in Fig. 1.1 by the plot symbol "4". Most of the structures at the Browns Ferry site are founded on rock. The hazard results for the rock case are given in Section 2.2 of Vol. III. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Browns Ferry site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.4.1 and Figs. 2.4.1 to 2.4.11 give the basic results most applicable to the structures founded on shallow soil at the Browns Ferry site.

In Section 2.2 of Vol. III we pointed out that for the rock case, distant zones made significant contribution to the BEHC for PGA at the Browns Ferry site. Thus as noted in Section 2.1, we find some significant differences between Table 2.4.1 and Table 2.2.1 of Vol. III. For the Sand-1 case, zones nearby the Browns Ferry site became more important.

If Fig. 2.4.2 is compared to Fig. 2.2.2 of Vol. III we see that, for example, the BEHC for S-Expert 11 has moved upwards relative to the other BEHCs per S-Expert.

We see from Fig. 2.4.4 that the median CPHC for the shallow soil case is much higher than the median CPHC for the rock case, however, there is relatively little difference between the 85th percentile CPHCs for the two cases.

The amplification of the PGA and the short period end of the spectra by the shallow soil is higher, as discussed in Section 3, than would might be expected based on the sensitivity results presented in Section 2.2 of Vol. VI.

TABLE 2.4.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR BROWNS FERRY S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 15	ZONE ID:	ZONE 9	ZONE 4	ZONE 10	ZONE 15	ZONE 9	ZONE 4	ZONE 10	ZONE 15
		% CONT.:	51.	32.	10.	2.	83.	12.	3.	3.
2	ZONE 27	ZONE ID:	ZONE 18	ZONE 27	ZONE 30	ZONE 20	ZONE 18	ZONE 27	COMP. ZON	ZONE 30
		% CONT.:	63.	31.	3.	1.	69.	31.	0.	0.
3	COMP. ZO	ZONE ID:	ZONE 5	ZONE 13	ZONE 12	COMP. ZON	ZONE 5	ZONE 13	COMP. ZON	ZONE 12
		% CONT.:	67.	19.	10.	4.	84.	8.	7.	1.
4	ZONE 13	ZONE ID:	ZONE 4	ZONE 8	ZONE 3	ZONE 5	ZONE 4	ZONE 8	ZONE 13	ZONE 3
		% CONT.:	87.	8.	1.	1.	98.	1.	1.	0.
5	COMP. ZO	ZONE ID:	ZONE 15	ZONE 11	ZONE 9	ZONE 14	ZONE 15	ZONE 11	COMP. ZON	ZONE 9
		% CONT.:	80.	13.	4.	2.	97.	1.	1.	0.
6	ZONE 12	ZONE ID:	ZONE 12	ZONE 17	ZONE 18	ZONE 13	ZONE 12	ZONE 18	ZONE 17	ZONE 13
		% CONT.:	59.	19.	14.	5.	85.	10.	4.	1.
7	ZONE 7	ZONE ID:	ZONE 6	ZONE 7	ZONE 5	ZONE 10	ZONE 6	ZONE 7	ZONE 5	ZONE 2 =
		% CONT.:	67.	30.	2.	0.	56.	44.	0.	0.
10	ZONE 19	ZONE ID:	ZONE 12A	ZONE 19 =	ZONE 28	ZONE 13	ZONE 19 =	ZONE 12A	ZONE 28	ZONE 13
		% CONT.:	43.	37.	17.	2.	85.	13.	2.	0.
11	ZONE 12	ZONE ID:	ZONE 12	ZONE 6	ZONE 11	CZ = ZONE	ZONE 12	ZONE 6	ZONE 11	CZ = ZONE
		% CONT.:	55.	23.	11.	5.	92.	3.	3.	1.
12	ZONE 4 =	ZONE ID:	ZONE 16	ZONE 15	ZONE 14	ZONE 19	ZONE 15	ZONE 16	ZONE 14	ZONE 19
		% CONT.:	33.	28.	13.	13.	86.	7.	6.	1.
13	CZ 15	ZONE ID:	ZONE 5	ZONE 8	CZ 15	ZONE 4	ZONE 5	CZ 15	ZONE 8	ZONE 4
		% CONT.:	45.	38.	14.	2.	41.	39.	19.	0.

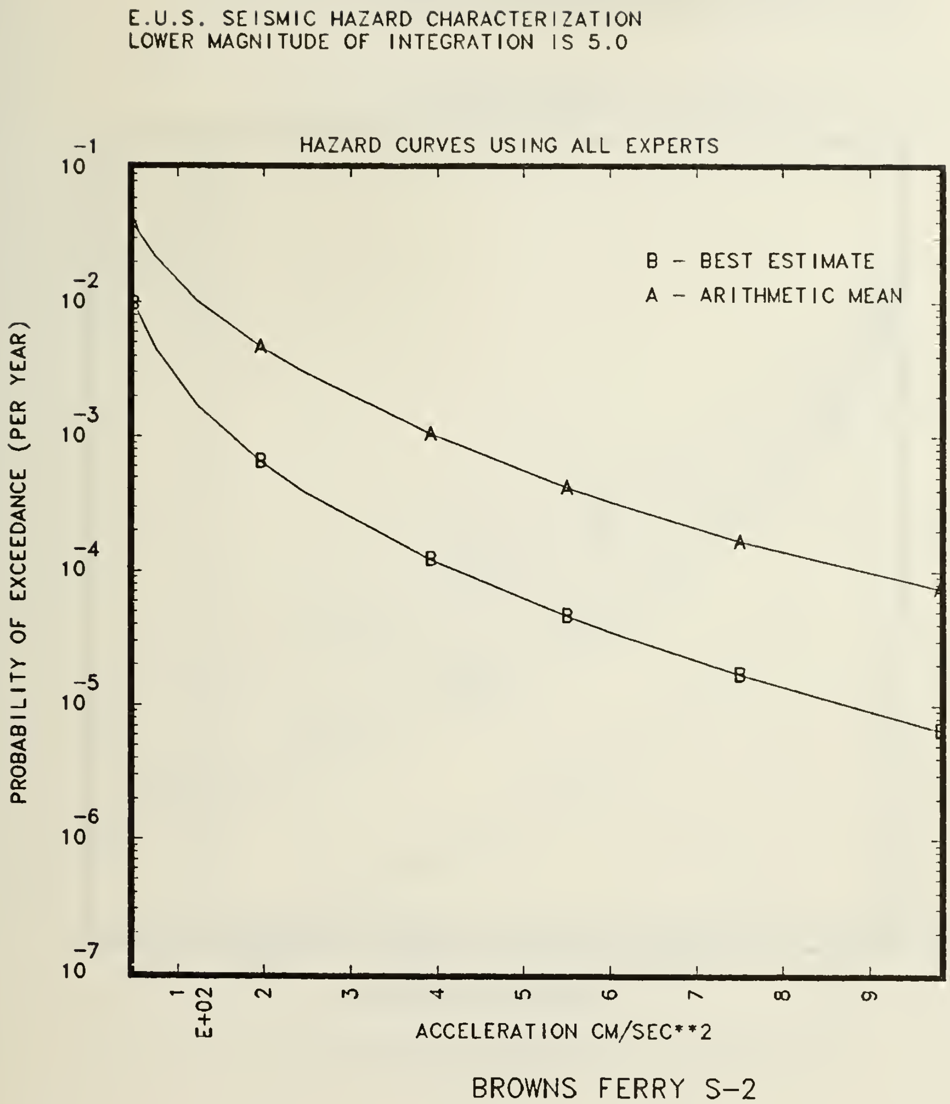


Figure 2.4.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Browns Ferry site.

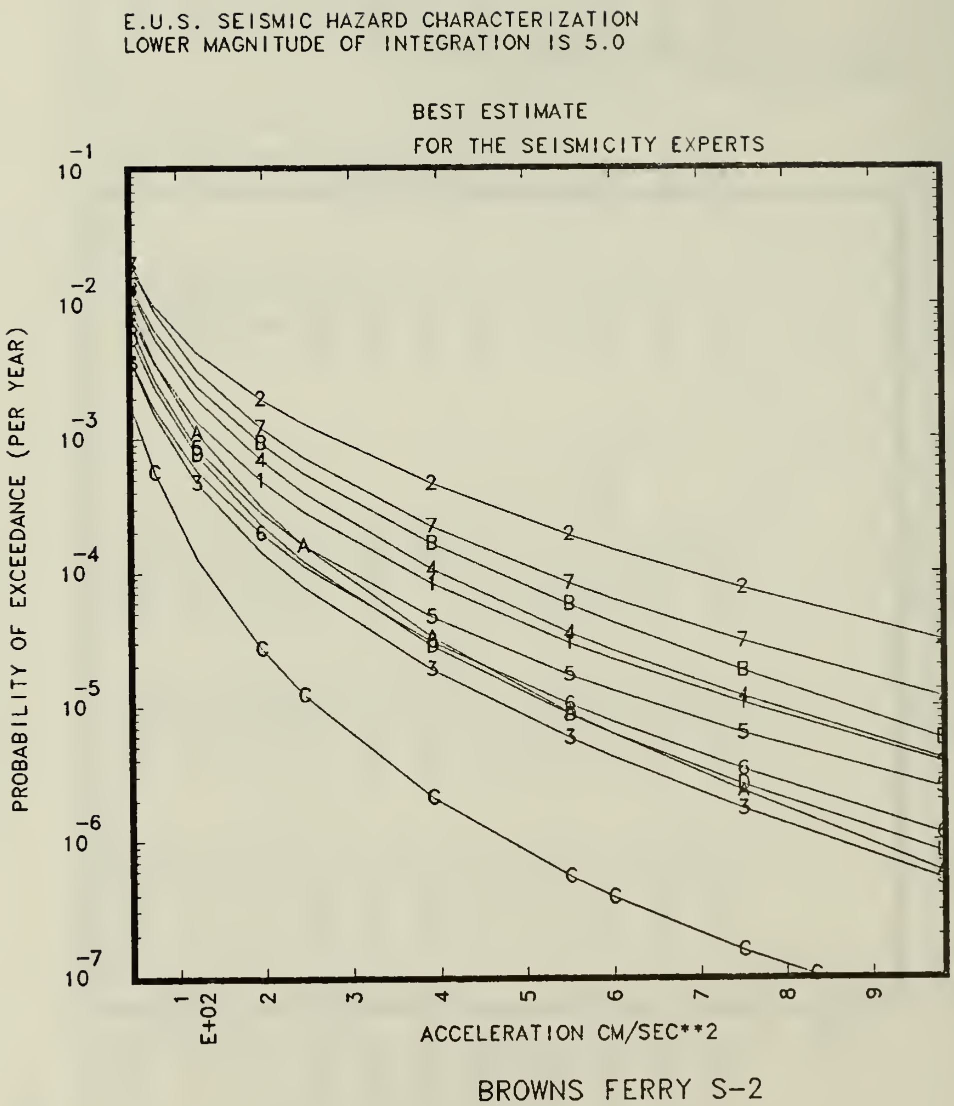


Figure 2.4.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Browns Ferry site. Plot symbols given in Table 2.0.

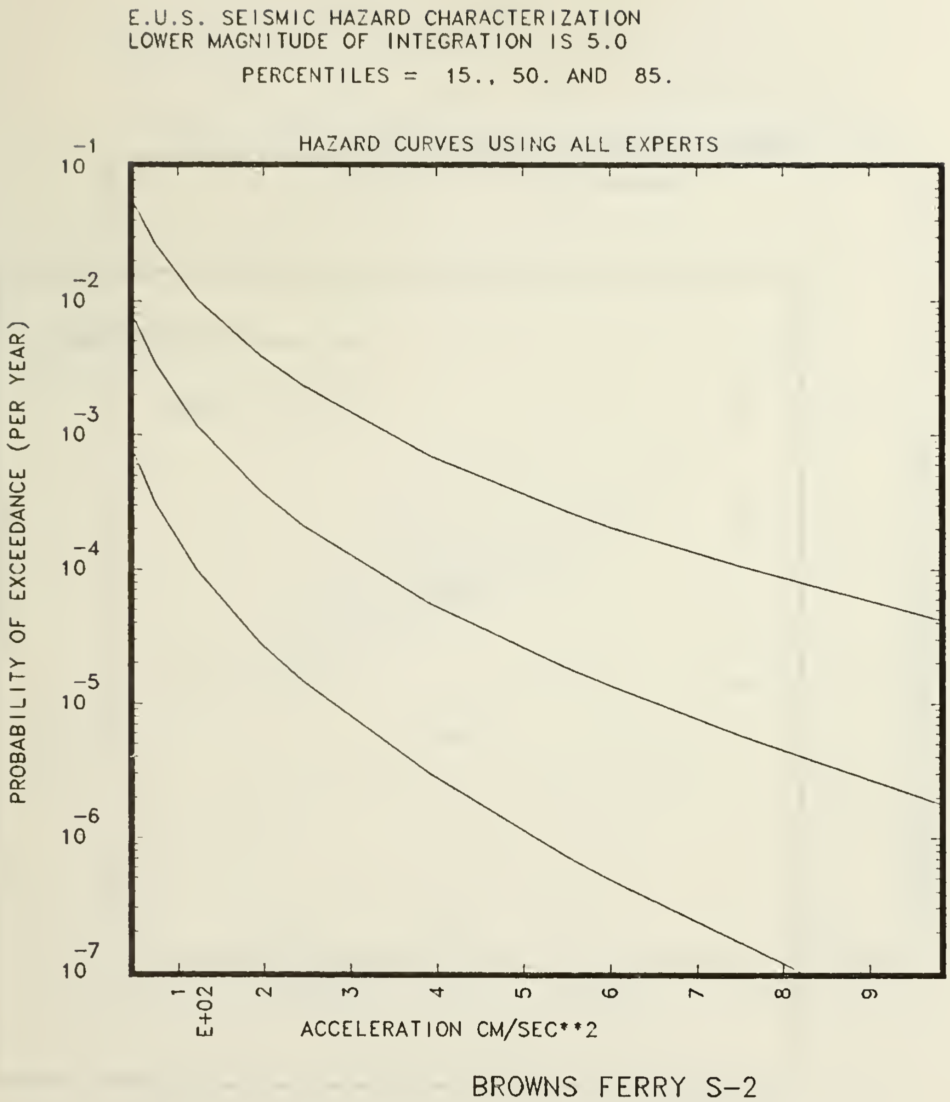


Figure 2.4.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Browns Ferry site.

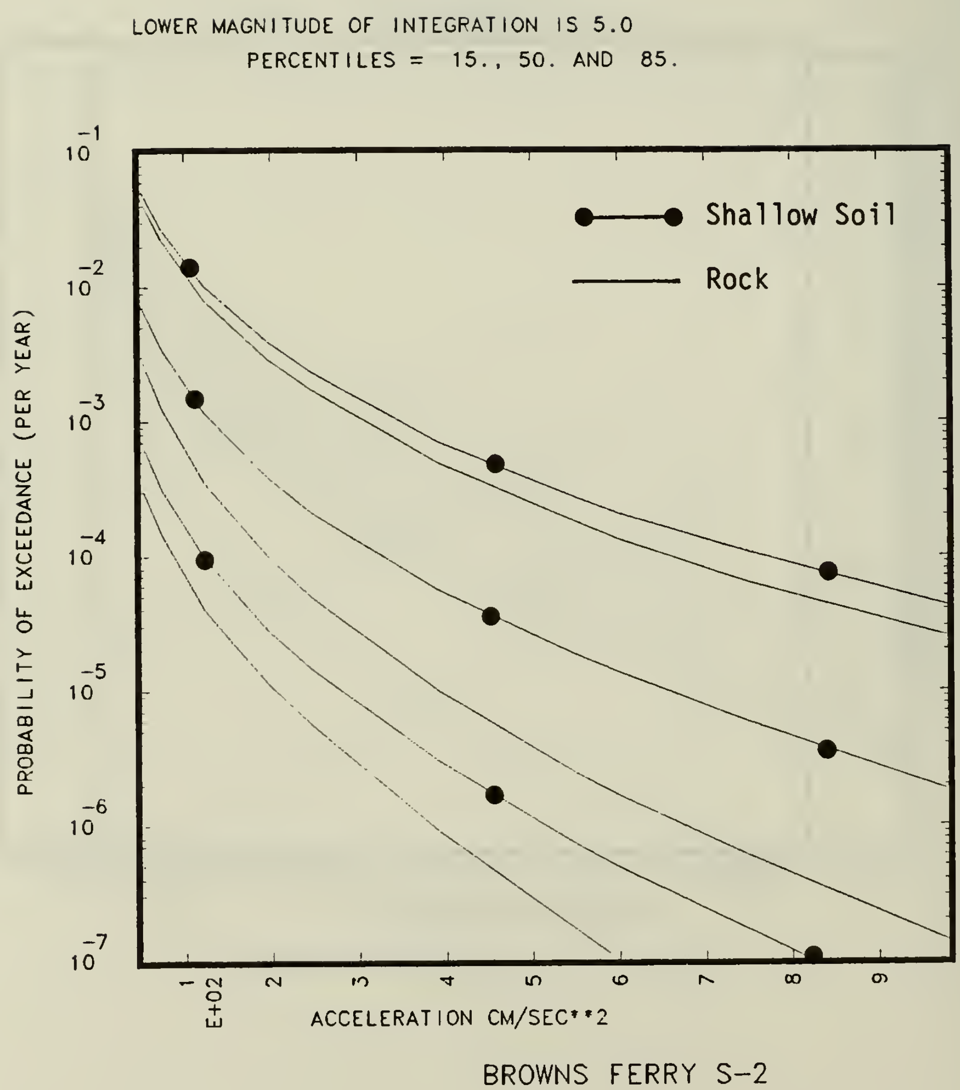


Figure 2.4.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Browns Ferry site.

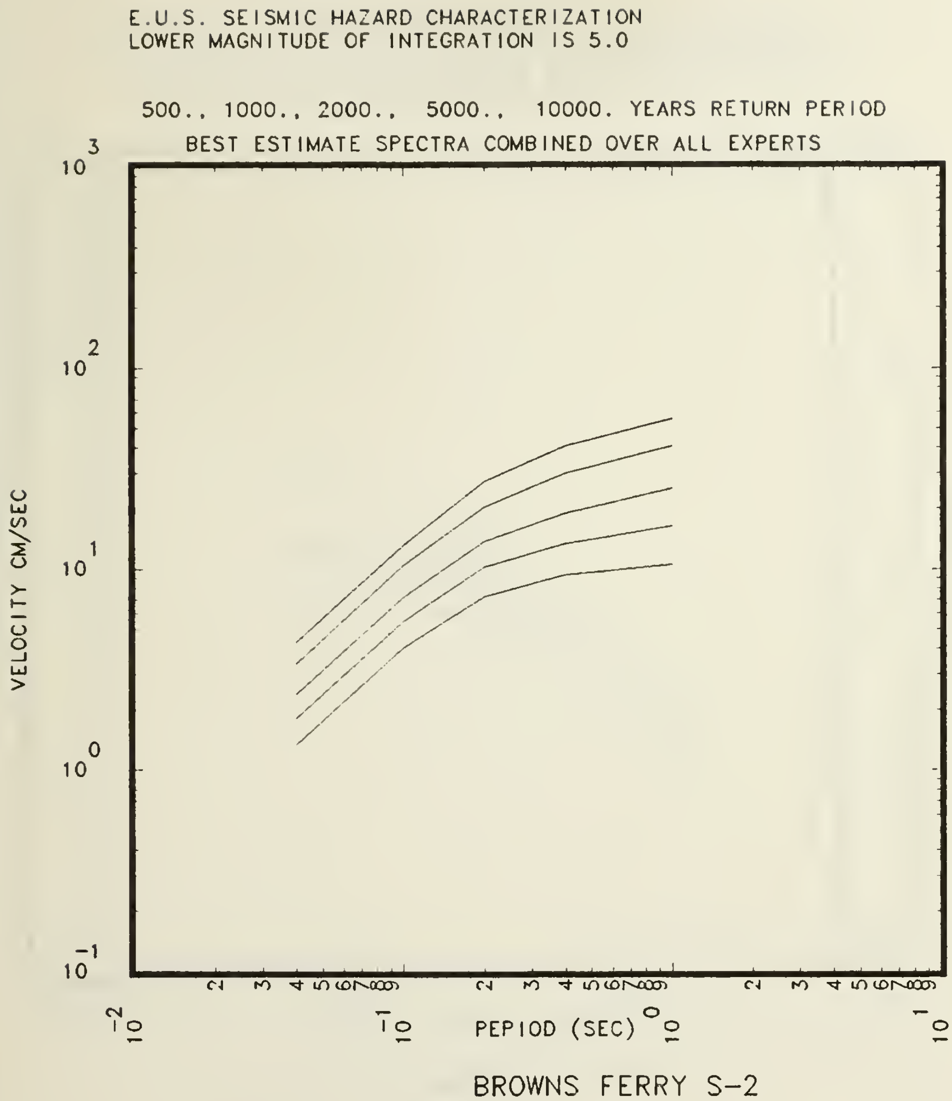


Figure 2.4.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Browns Ferry site.

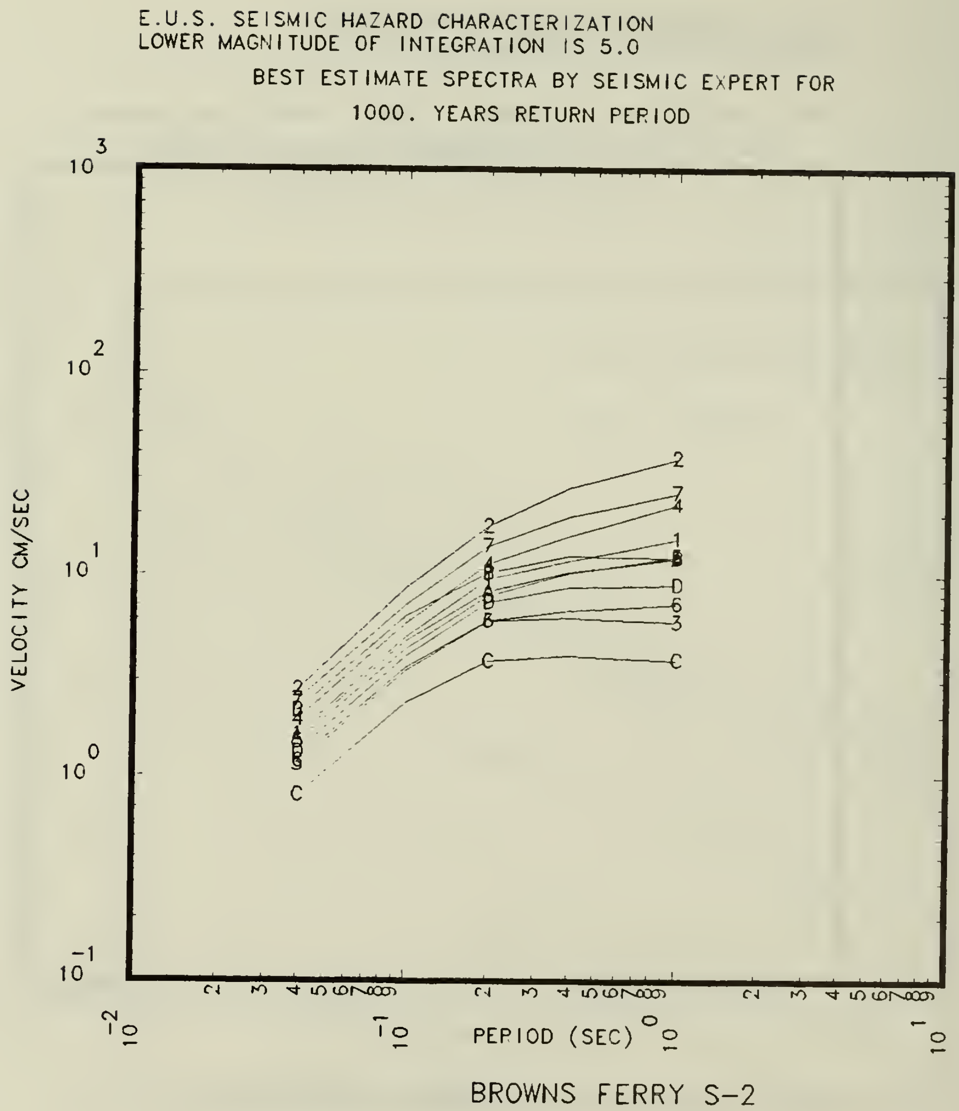


Figure 2.4.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Browns Ferry site. Plot symbols are given in Table 2.0

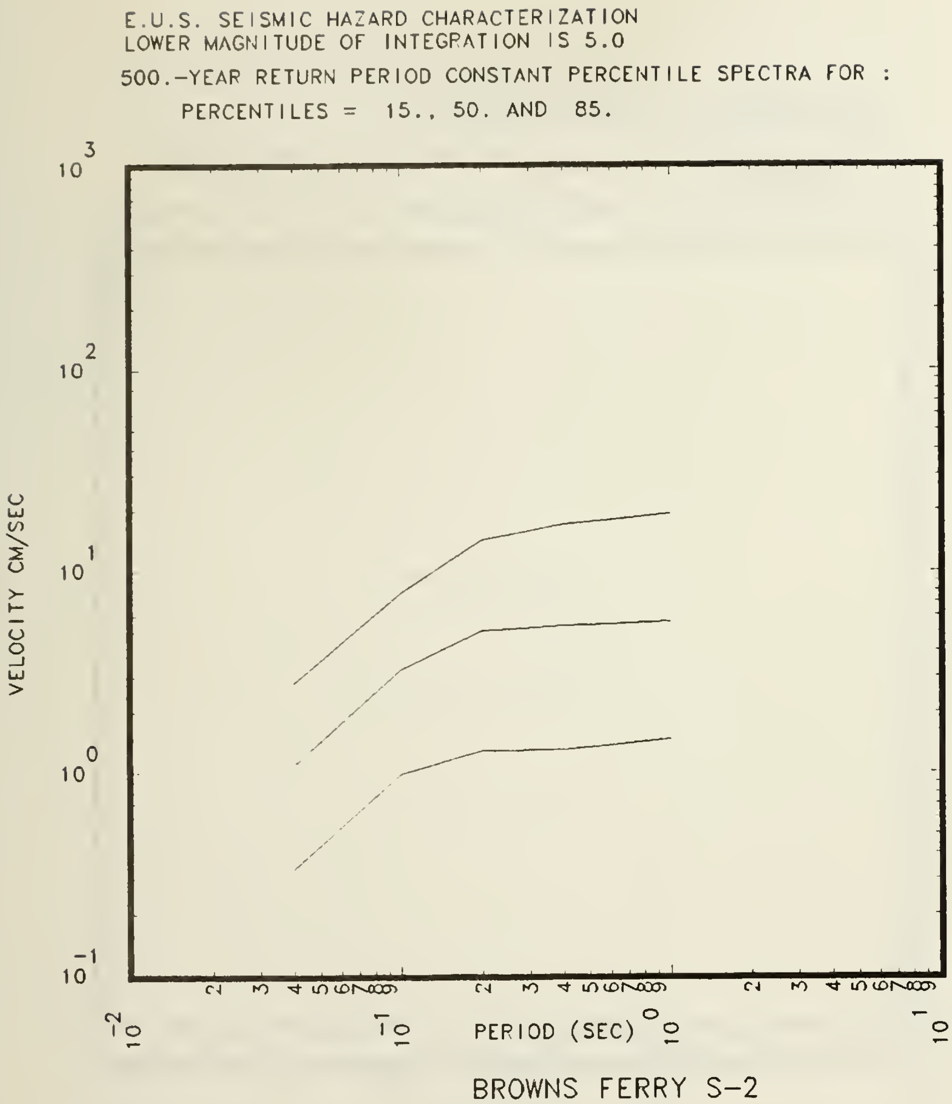


Figure 2.4.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Browns Ferry site.

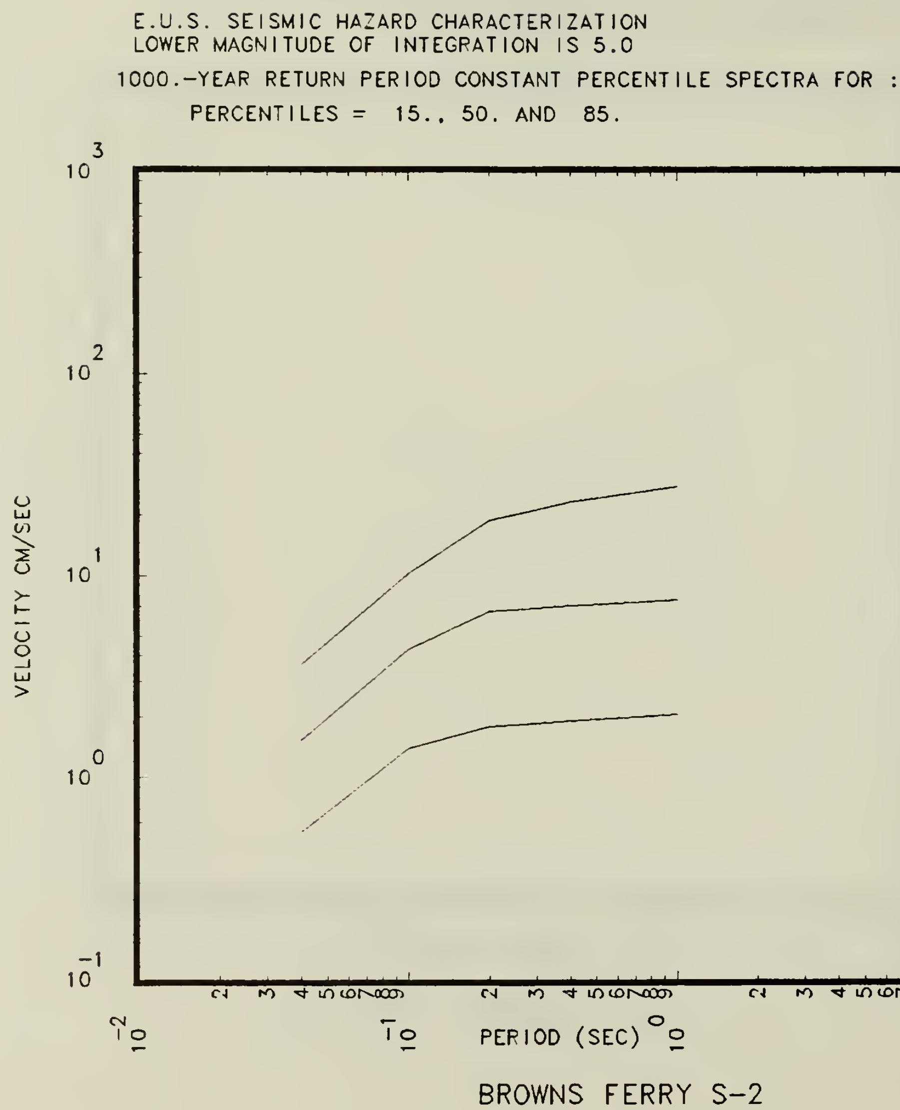


Figure 2.4.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Browns Ferry site.

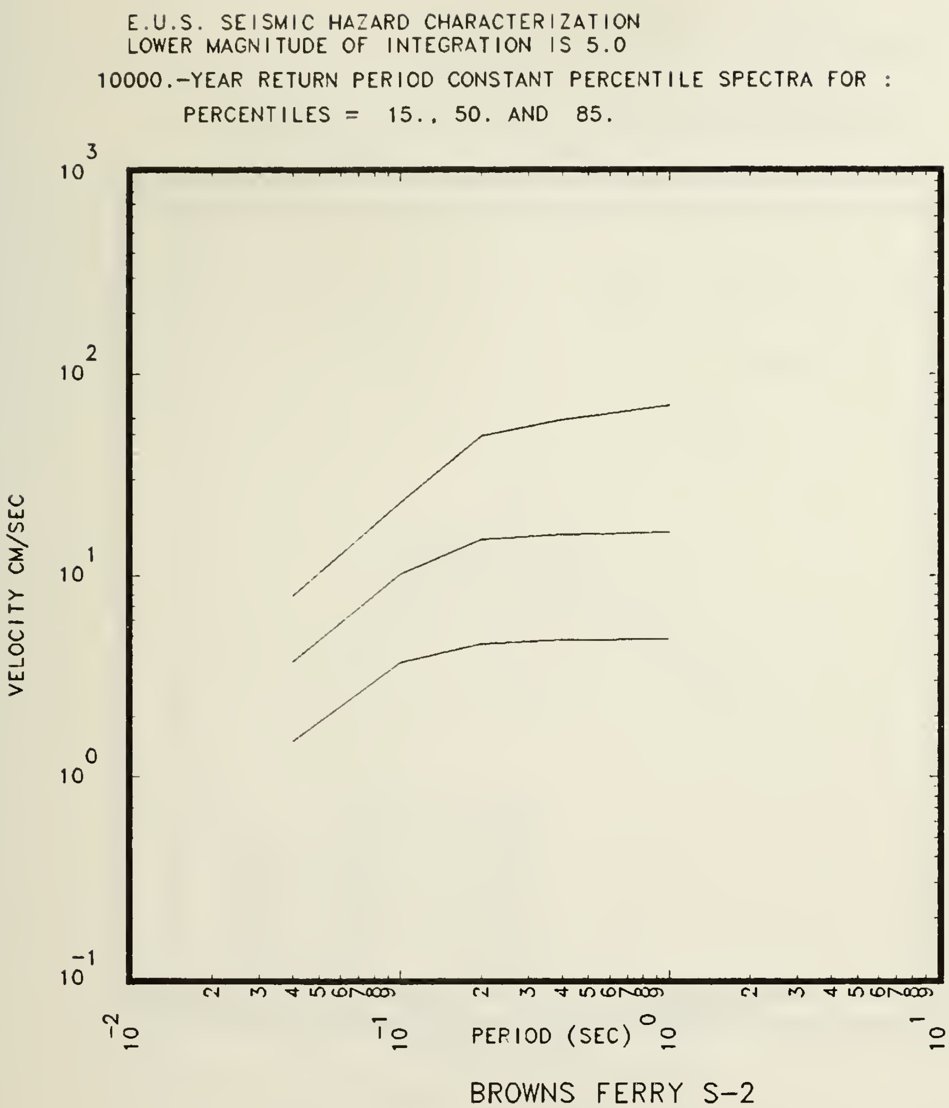


Figure 2.4.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Browns Ferry site.

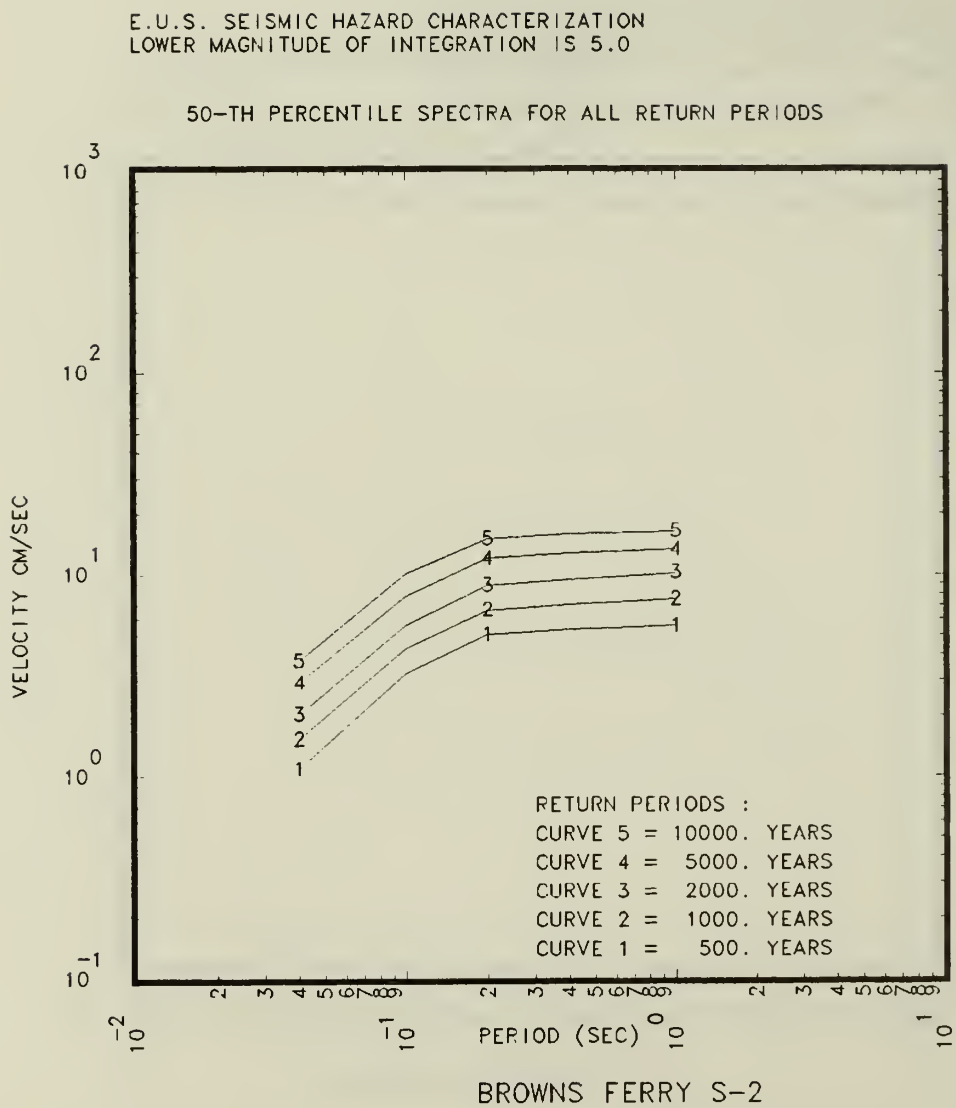


Figure 2.4.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Browns Ferry site.

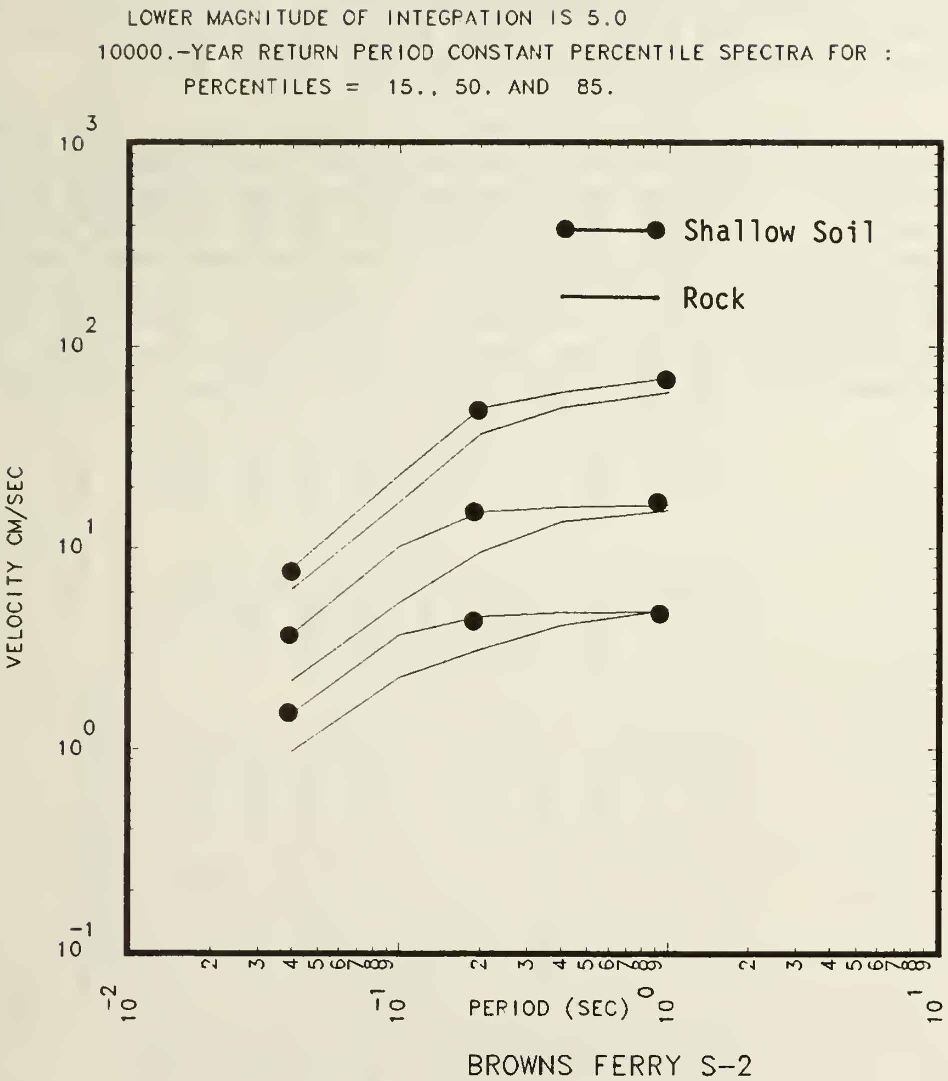


Figure 2.4.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Browns Ferry site.

2.5 Catawba

The location of the Catawba site is shown in Fig. 1.1 by the plot symbol "5". Most of the structures at the Catawba site are founded on rock. The hazard results for the rock case are given in Section 2.9 of Vol. III. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Catawba site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.5.1 and Figs. 2.5.1 to 2.5.11 give the basic results most applicable to the structures founded on shallow soil at the Catawba site.

For the rock case distant zones are somewhat more important at the Catawba site than they are at say the Susquehanna site, but less important than at say the Browns Ferry site. Thus we see a number of changes in Table 2.5.1 as compared to Table 2.5.1 in Vol. III. Typically, the change observed is that the percent contribution to the BEHC for PGA from the zones near the site are higher for the shallow soil case as compared to the rock case given in Vol. III. In addition we see, as discussed in Section 3, from Fig. 2.5.4 that the amplification of the PGA between the shallow soil and rock cases is larger than would be expected from the sensitivity results present in Vol. VI.

TABLE 2.5.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR CATAWBA S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 3	ZONE ID:	ZONE 3	ZONE 2	ZONE 9	ZONE 4	ZONE 3	ZONE 2	ZONE 9	ZONE 1
		% CONT.:	75.	14.	5.	3.	96.	2.	1.	0.
2	ZONE 29	ZONE ID:	ZONE 30	ZONE 29	ZONE 27	ZONE 18	ZONE 29	ZONE 30	ZONE 18	ZONE 27
		% CONT.:	46.	38.	8.	7.	64.	32.	2.	2.
3	ZONE 7	ZONE ID:	ZONE 7	ZONE 9	ZONE 5	ZONE 13	ZONE 7	ZONE 9	ZONE 5	COMP. ZON
		% CONT.:	77.	13.	8.	1.	98.	2.	0.	0.
4	ZONE 9	ZONE ID:	ZONE 10	ZONE 9	ZONE 4	ZONE 11	ZONE 9	ZONE 10	ZONE 11	ZONE 4
		% CONT.:	47.	43.	4.	3.	84.	15.	1.	0.
5	ZONE 10	ZONE ID:	ZONE 9	ZONE 10	ZONE 11	ZONE 15	ZONE 10	ZONE 9	ZONE 15	ZONE 11
		% CONT.:	57.	35.	4.	3.	52.	46.	1.	0.
6	ZONE 13	ZONE ID:	ZONE 13	ZONE 11	COMP. ZON	ZONE 17	ZONE 13	ZONE 11	COMP. ZON	ZONE 6
		% CONT.:	86.	13.	1.	0.	98.	2.	0.	0.
7	ZONE 8	ZONE ID:	ZONE 8	ZONE 10	ZONE 6	ZONE 7	ZONE 8	ZONE 10	ZONE 6	ZONE 7
		% CONT.:	54.	23.	14.	8.	84.	12.	3.	1.
10	ZONE 28	ZONE ID:	ZONE 28	ZONE 4B	ZONE 15	ZONE 28A	ZONE 28	ZONE 4B	ZONE 19 =	ZONE 15
		% CONT.:	84.	7.	5.	3.	99.	1.	0.	0.
11	ZONE 7	ZONE ID:	ZONE 7	ZONE 8	ZONE 6	ZONE 11	ZONE 7	ZONE 8	CZ = ZONE	ZONE 6
		% CONT.:	79.	17.	3.	0.	86.	12.	2.	0.
12	ZONE 21	ZONE ID:	ZONE 22	ZONE 21	ZONE 20	ZONE 23A	ZONE 21	ZONE 22	ZONE 23A	ZONE 20
		% CONT.:	27.	26.	25.	18.	67.	21.	9.	3.
13	CZ 17	ZONE ID:	CZ 17	ZONE 9	ZONE 8	ZONE 5	CZ 17	ZONE 9	CZ 15	ZONE 8
		% CONT.:	59.	24.	13.	2.	89.	8.	2.	1.

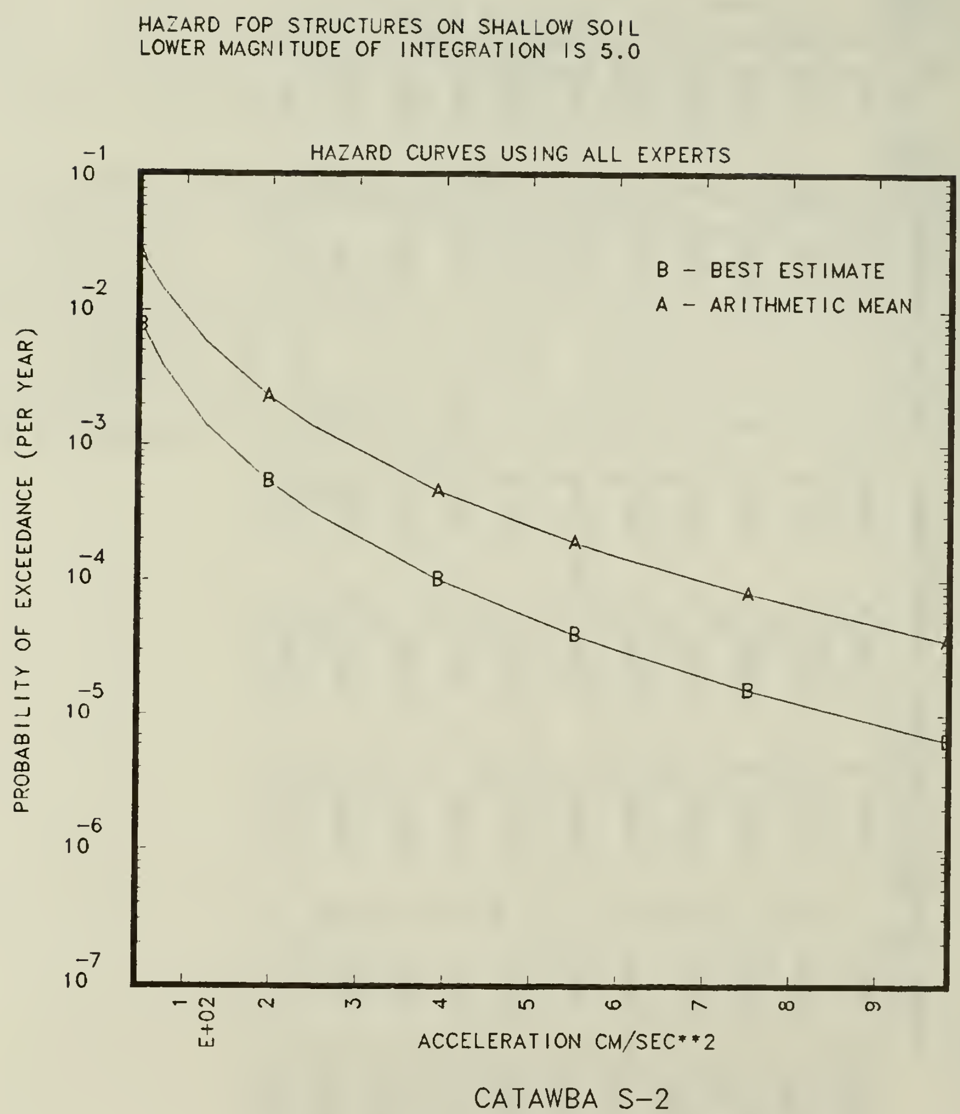


Figure 2.5.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Catawba site.

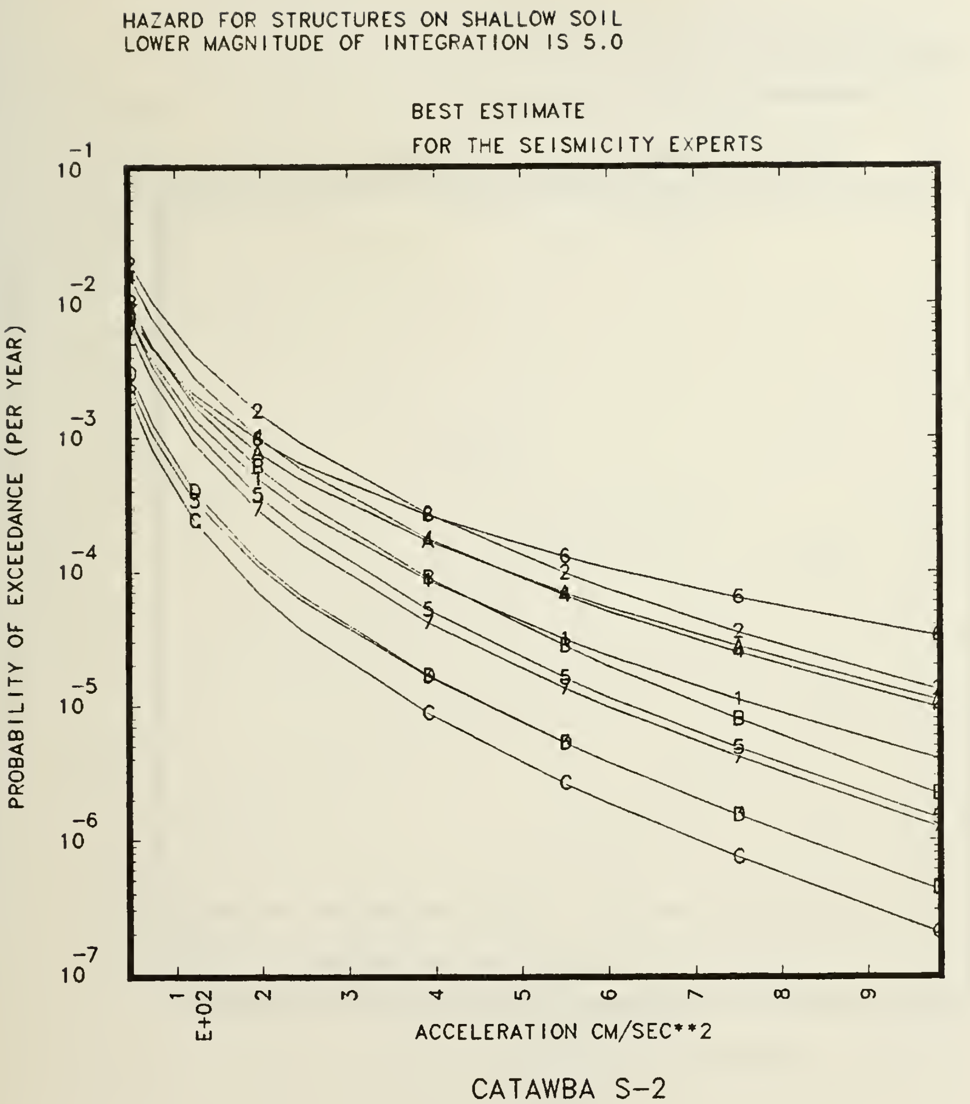


Figure 2.5.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Catawba site. Plot symbols given in Table 2.0.

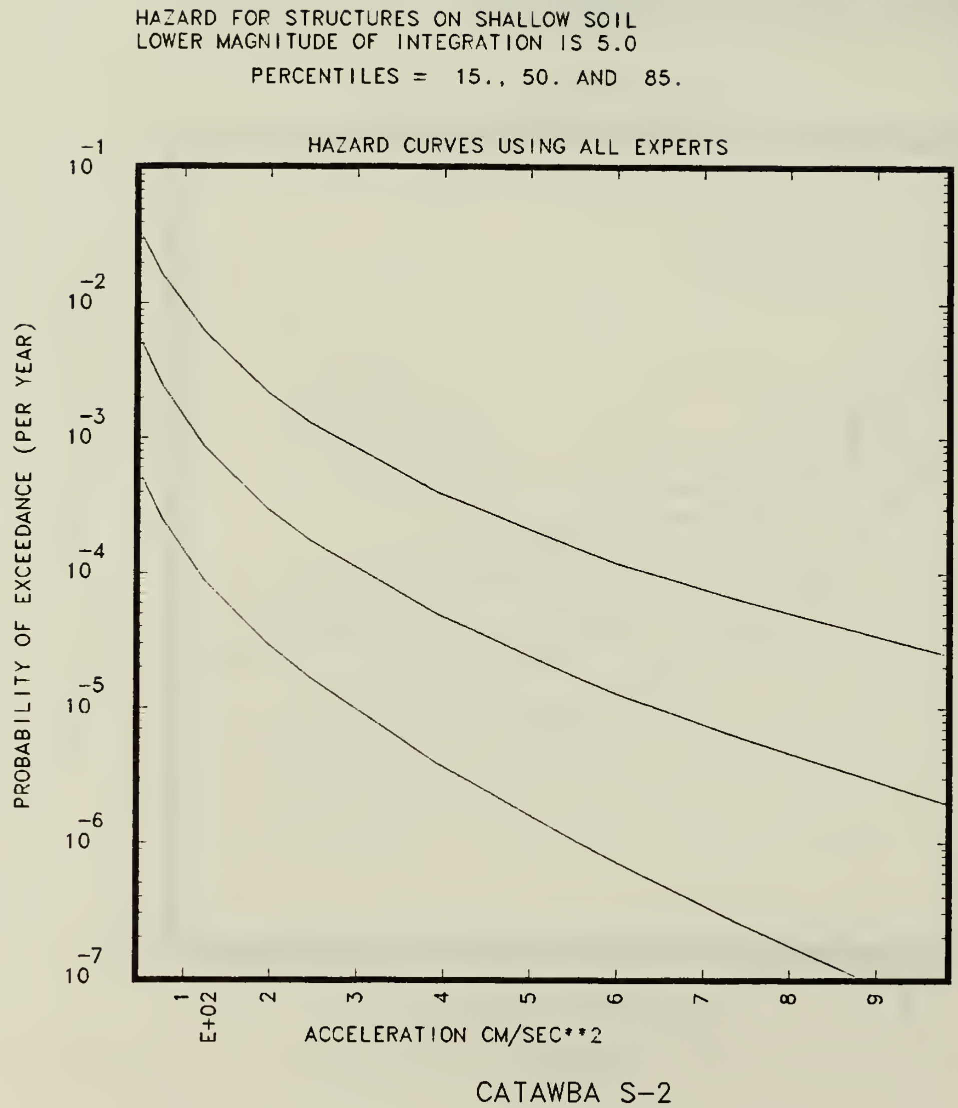


Figure 2.5.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Catawba site.

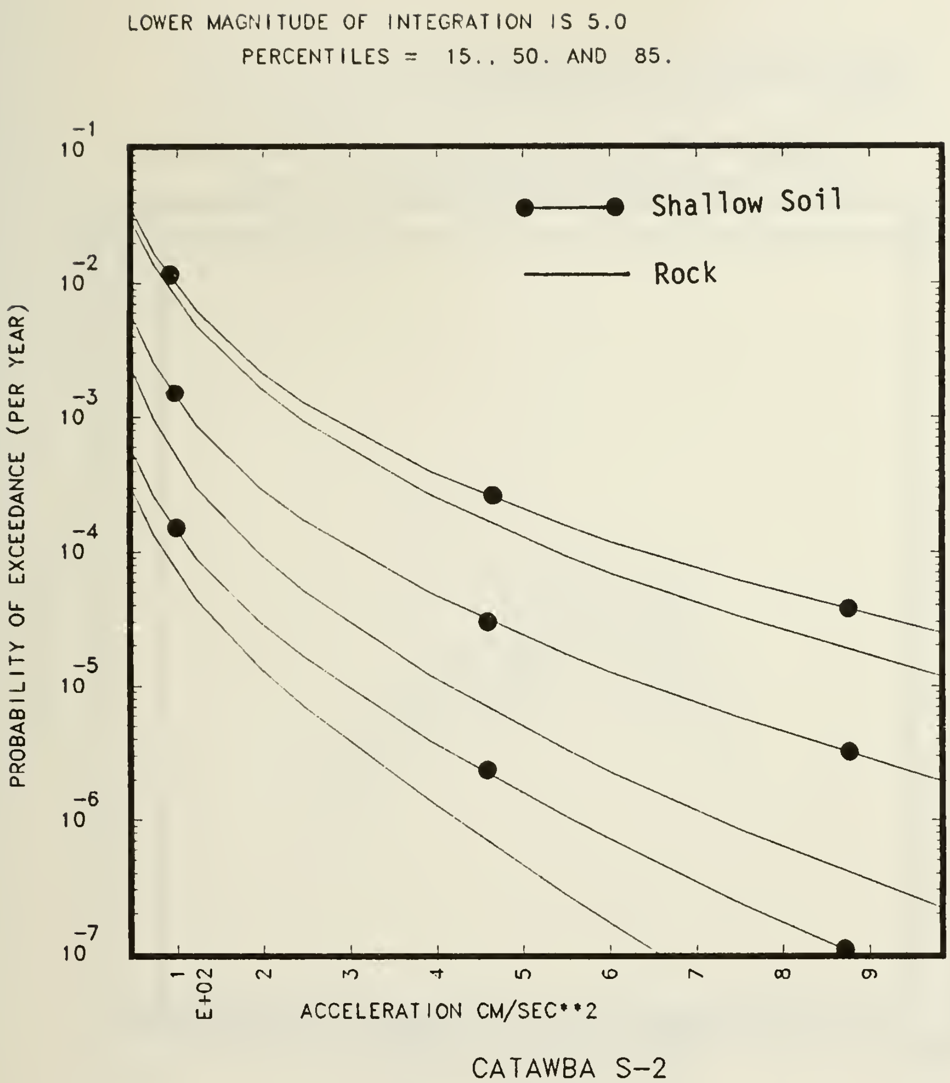


Figure 2.5.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Catawba site.

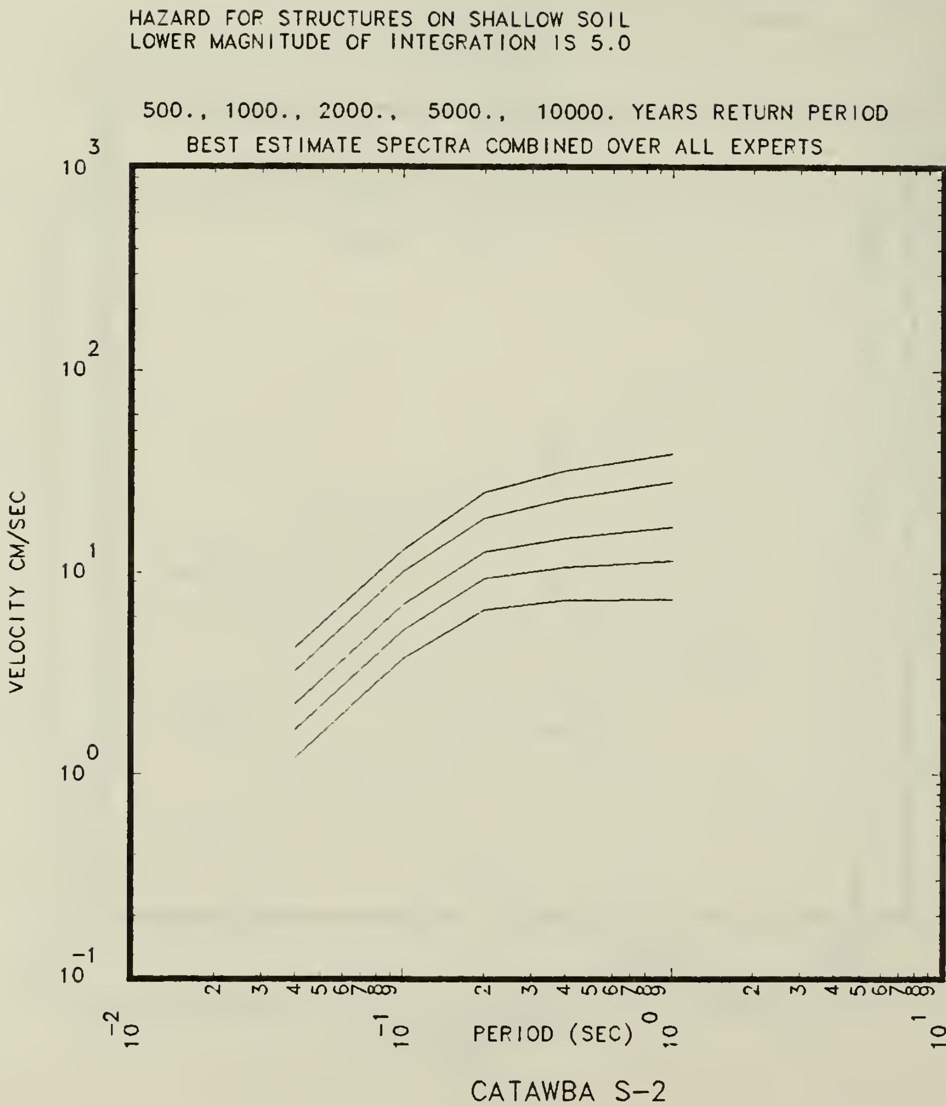


Figure 2.5.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Catawba site.

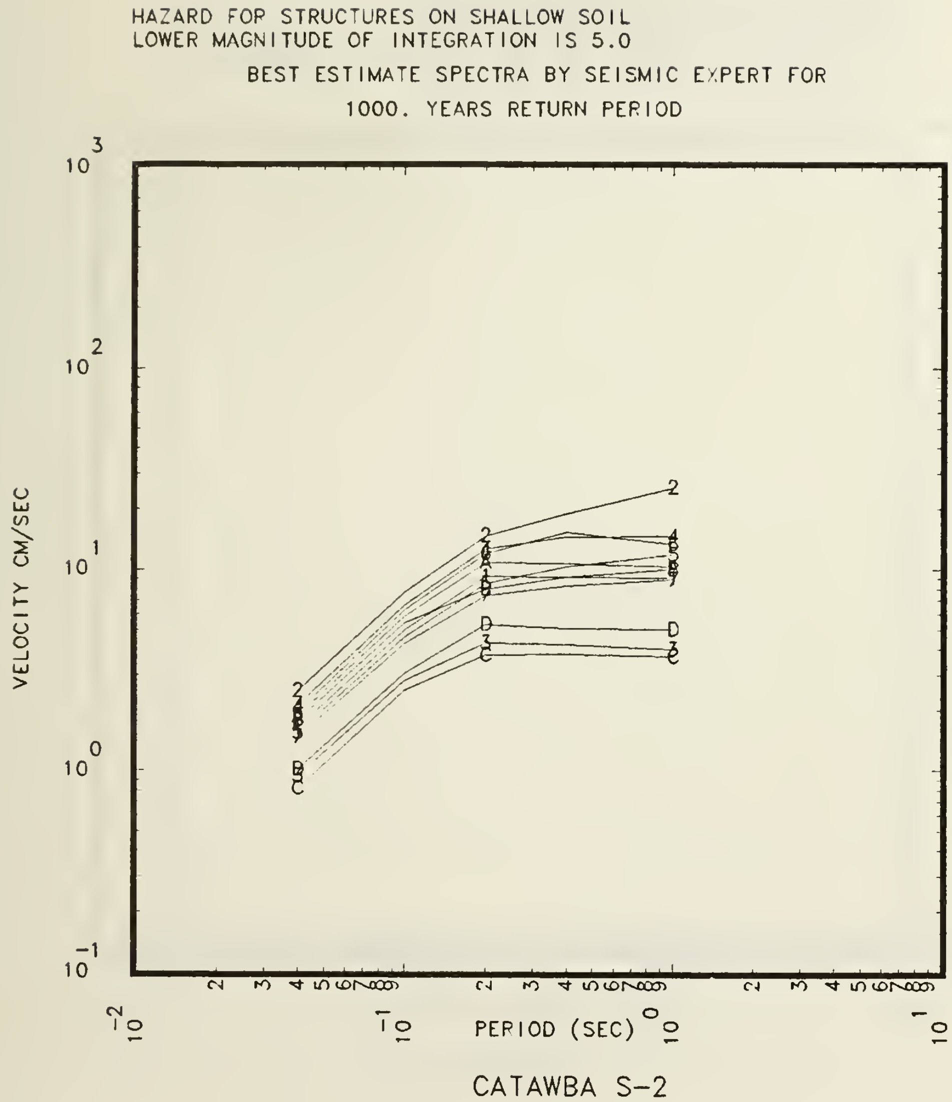


Figure 2.5.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Catawba site. Plot symbols are given in Table 2.0

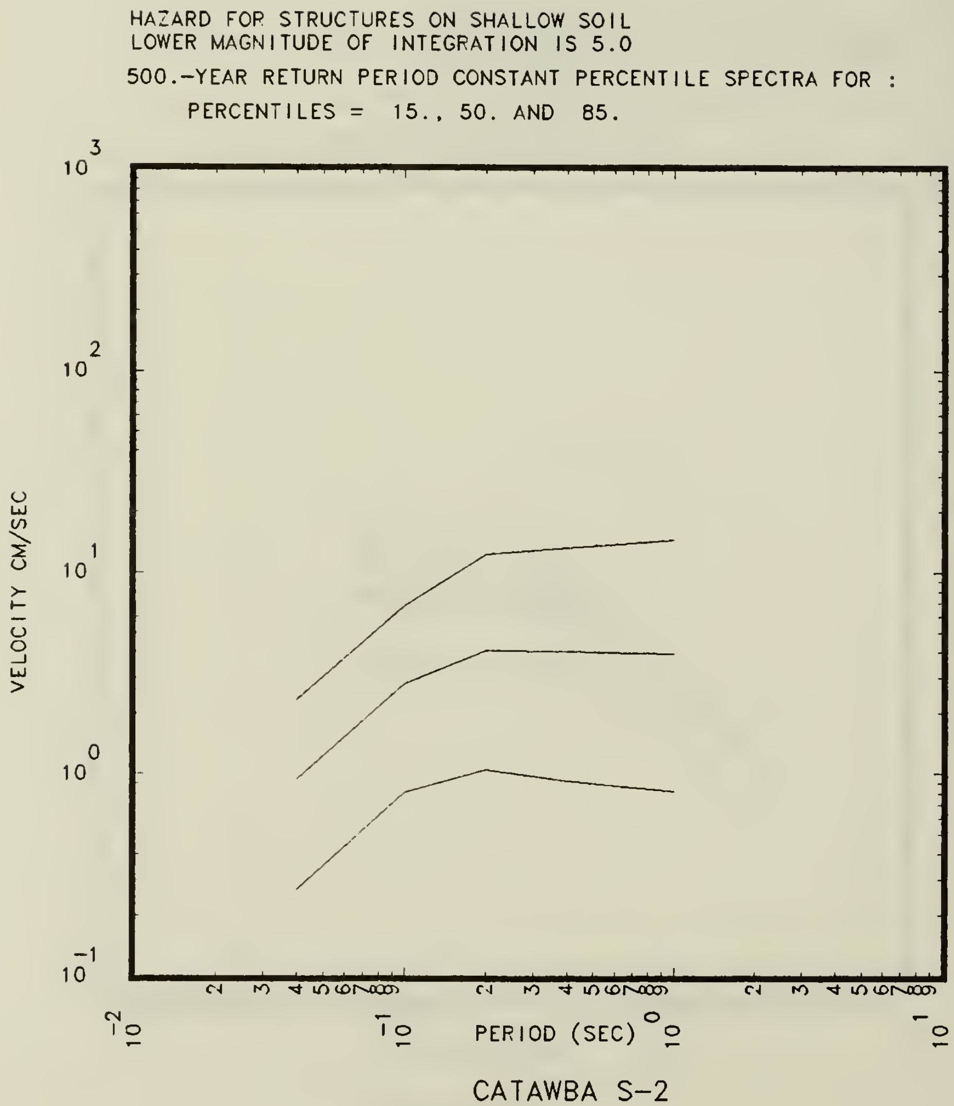


Figure 2.5.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Catawba site.

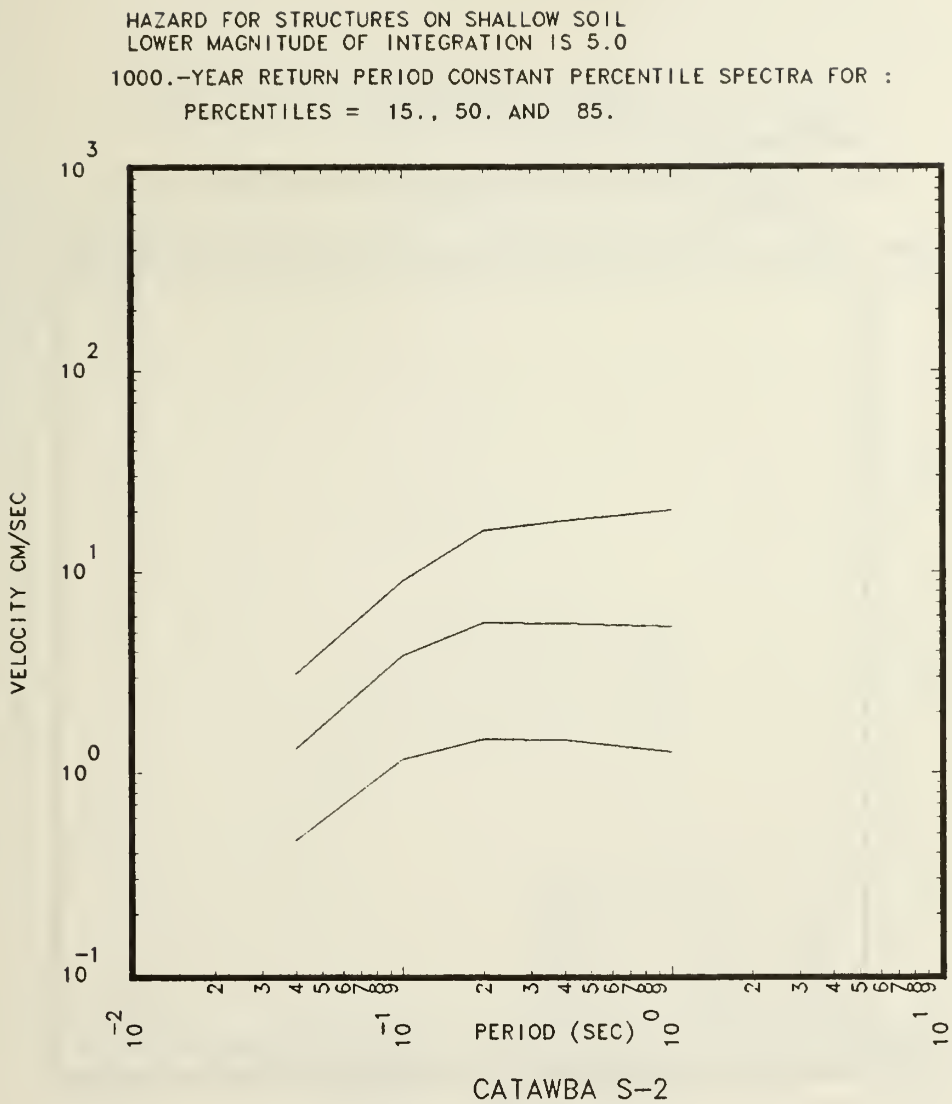


Figure 2.5.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Catawba site.

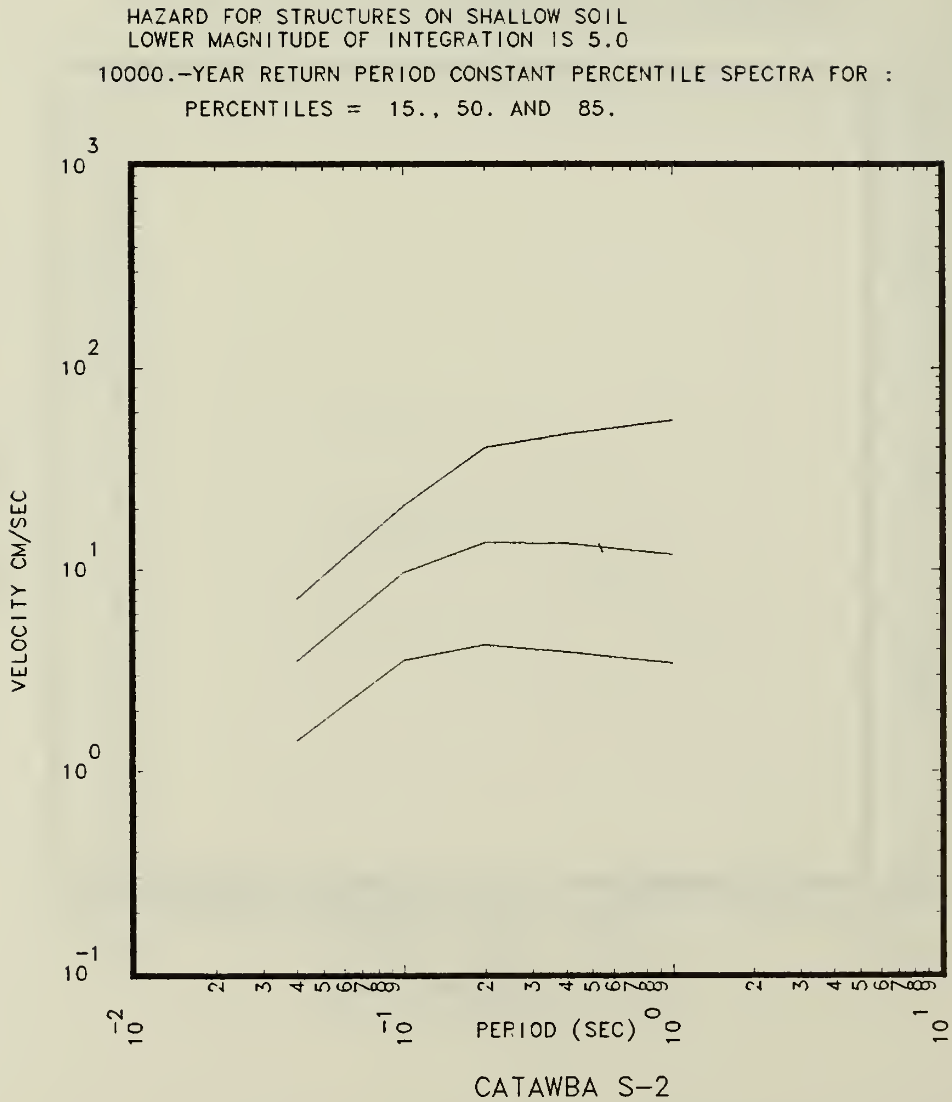


Figure 2.5.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Catawba site.

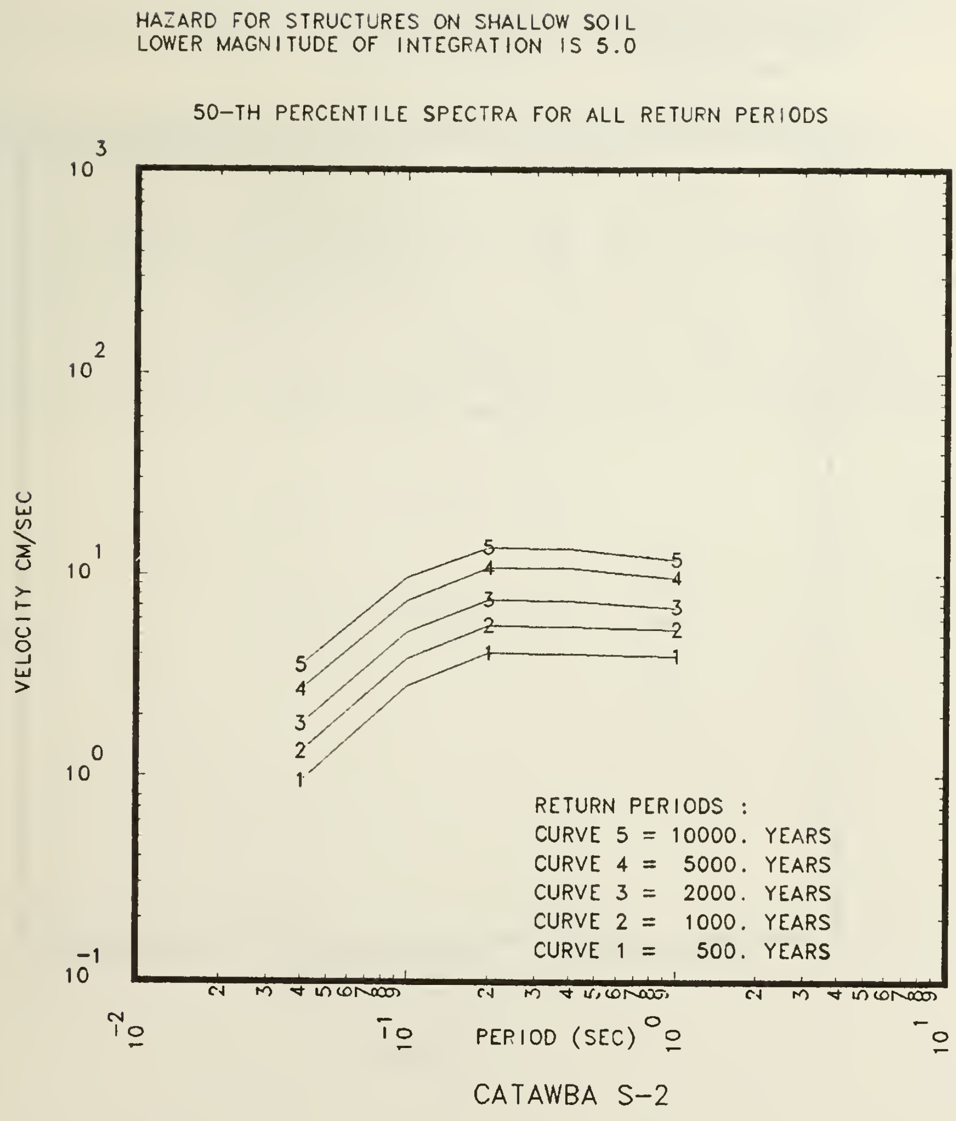


Figure 2.5.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Catawba site.

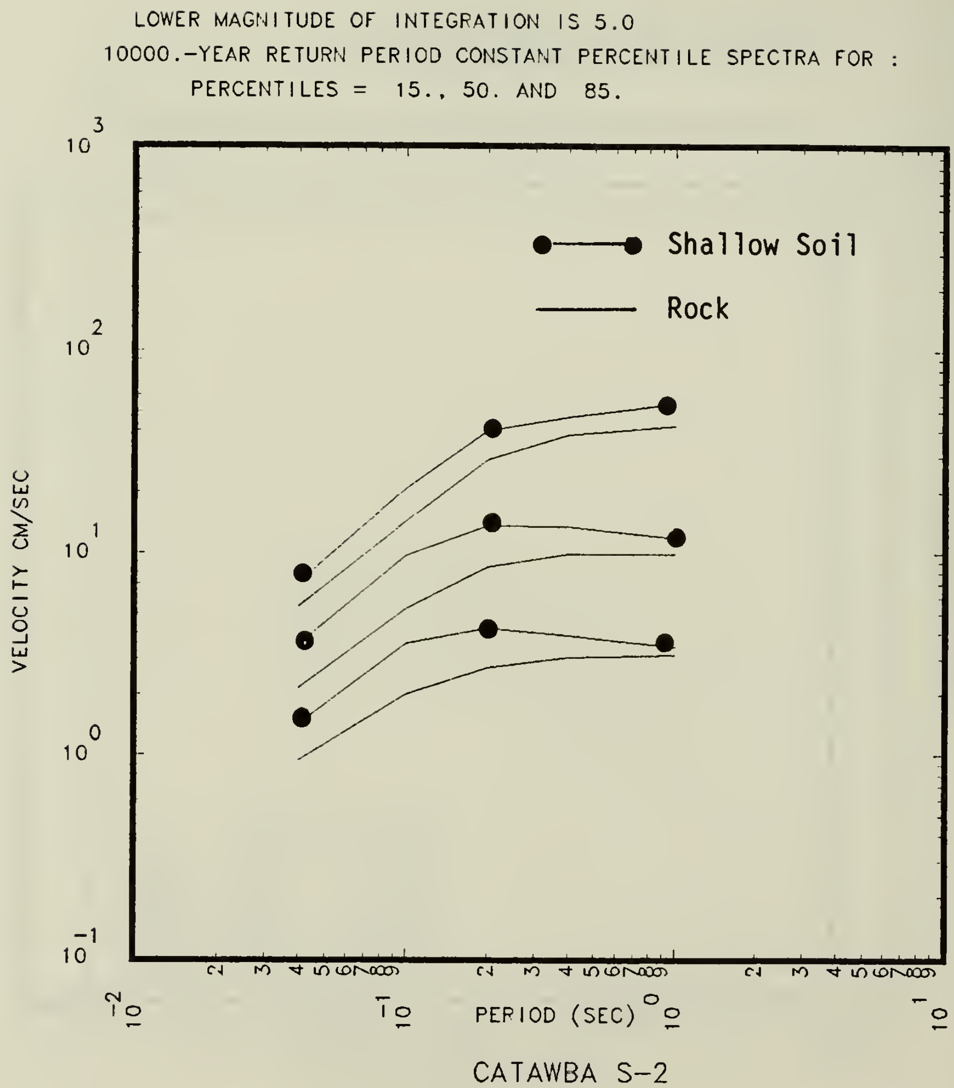


Figure 2.5.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Catawba site.

2.6 Farley

The location of the Farley site is shown in Fig. 1.1 by the plot symbol "6". Most of the structures at the Farley site are founded on rock. The hazard results for the rock case are given in Section 2.6 of Vol. III. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Farley site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.6.1 and Figs. 2.6.1 to 2.6.11 give the basic results most applicable to the structures founded on shallow soil at the Farley site.

As discussed in Section 2.6 of Vol. III, distant zones make a significant contribution to the BEHC for PGA for the rock case. Thus there are significant differences between Table 2.6.1 for the shallow soil case and Table 2.6.1 of Vol. III for the rock case for the Farley site because, the shallow soil amplifies the ground motion from smaller nearby earthquakes making the nearby zones more important. The difference between the median CPHCs for the rock and shallow soil cases shown in Fig. 2.6.4 are somewhat larger than might be expected from the sensitivity results present in Vol. VI, however, it is much less than the difference between medians observed at the Browns Ferry site in Fig. 2.4.4. The reasons for this are discussed in Section 3.

TABLE 2.6.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR FARLEY S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 1	ZONE ID:	ZONE 1	ZONE 9	ZONE 3	ZONE 10	ZONE 1	ZONE 9	ZONE 3	ZONE 2
		% CONT.:	72.	20.	3.	2.	94.	6.	0.	0.
2	COMP. ZO	ZONE ID:	ZONE 18	ZONE 30	COMP. ZON	ZONE 27	COMP. ZON	ZONE 18	ZONE 30	ZONE 27
		% CONT.:	45.	36.	16.	2.	43.	41.	16.	0.
3	ZONE 8A	ZONE ID:	ZONE 8A	COMP. ZON	ZONE 5	ZONE 13	ZONE 8A	COMP. ZON	ZONE 13	ZONE 5
		% CONT.:	81.	8.	4.	3.	99.	1.	0.	0.
4	ZONE 25	ZONE ID:	ZONE 4	ZONE 9	ZONE 10	ZONE 8	ZONE 4	ZONE 25	ZONE 9	ZONE 10
		% CONT.:	68.	10.	10.	6.	78.	18.	2.	1.
5	ZONE 8	ZONE ID:	ZONE 10	ZONE 9	ZONE 15	ZONE 8	ZONE 8	ZONE 15	ZONE 9	ZONE 10
		% CONT.:	36.	26.	22.	11.	55.	22.	11.	10.
6	COMP. ZO	ZONE ID:	ZONE 13	COMP. ZON	ZONE 18	ZONE 17	COMP. ZON	ZONE 13	ZONE 18	ZONE 17
		% CONT.:	51.	35.	6.	5.	76.	23.	1.	0.
7	ZONE 2 =	ZONE ID:	ZONE 6	ZONE 2 =	ZONE 10	ZONE 7	ZONE 6	ZONE 2 =	ZONE 10	ZONE 7
		% CONT.:	71.	16.	10.	2.	57.	40.	3.	0.
10	ZONE 19	ZONE ID:	ZONE 19 =	ZONE 28	ZONE 4B	ZONE 12A	ZONE 19 =	ZONE 28	ZONE 4B	ZONE 15
		% CONT.:	84.	8.	3.	3.	100.	0.	0.	0.
11	ZONE 8	ZONE ID:	ZONE 8	ZONE 11	ZONE 7	CZ = ZONE	ZONE 8	CZ = ZONE	ZONE 11	ZONE 5
		% CONT.:	96.	1.	1.	1.	100.	0.	0.	0.
12	ZONE 26	ZONE ID:	ZONE 23A	ZONE 19	ZONE 15	ZONE 25	ZONE 15	ZONE 23A	ZONE 25	ZONE 19
		% CONT.:	28.	25.	19.	17.	57.	27.	15.	1.
13	CZ 16	ZONE ID:	CZ 16	ZONE 5	ZONE 8	ZONE 9	CZ 16	ZONE 5	CZ 15	ZONE 9
		% CONT.:	43.	33.	11.	11.	81.	12.	6.	1.

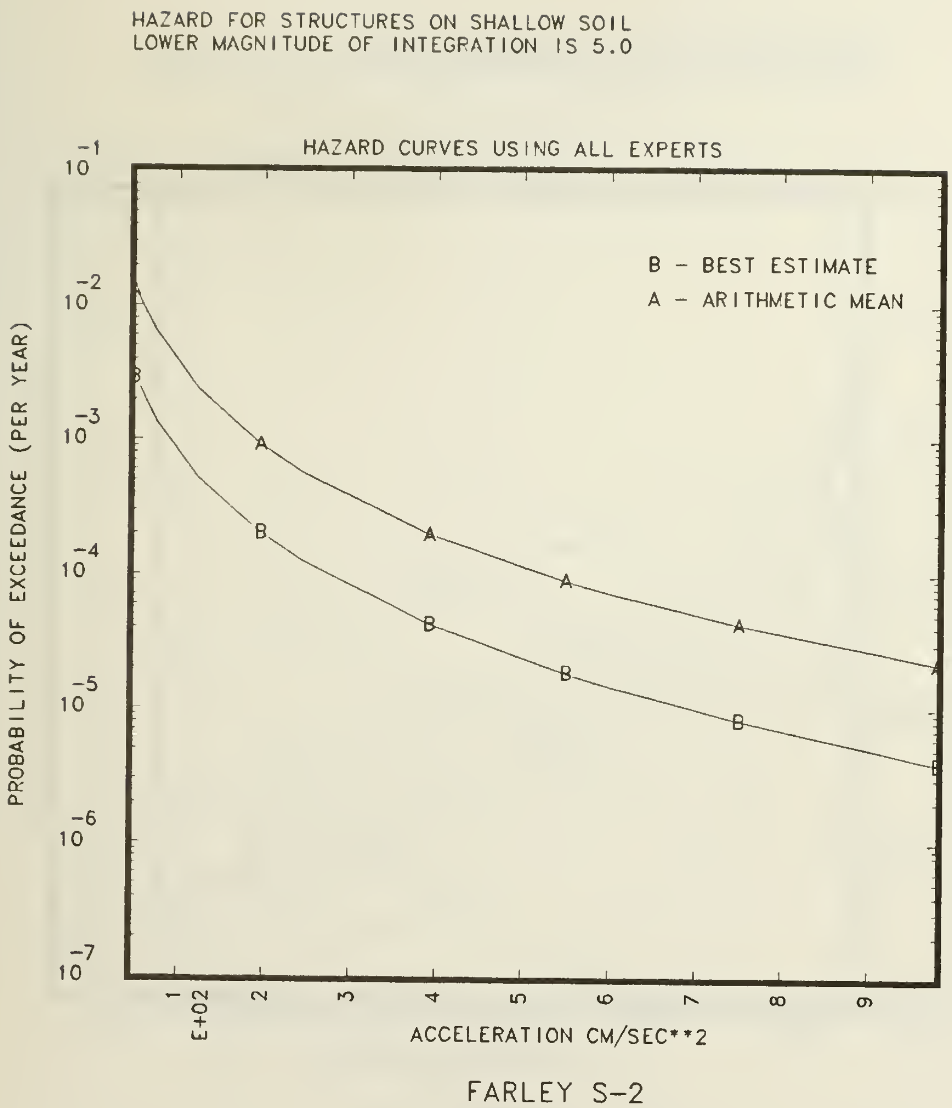


Figure 2.6.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Farley site.

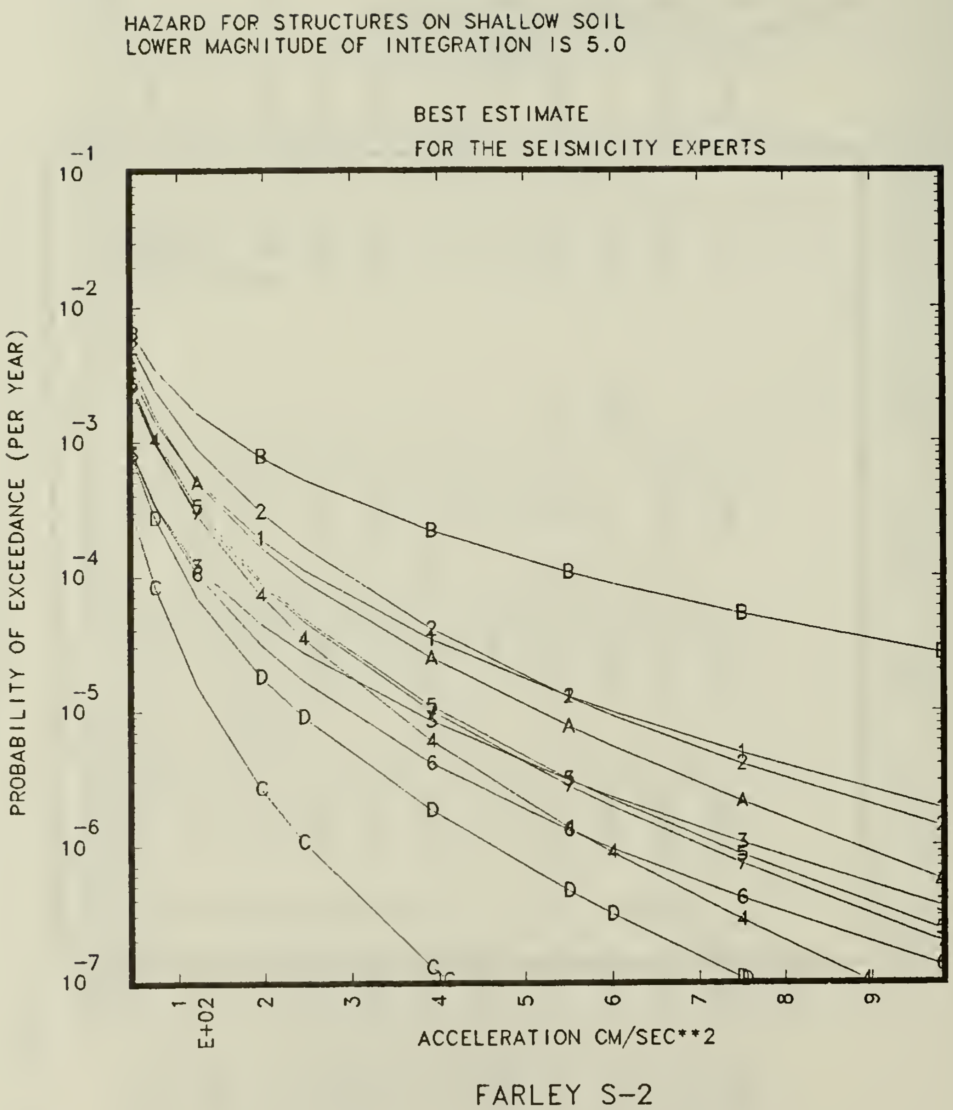


Figure 2.6.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Farley site. Plot symbols given in Table 2.0.

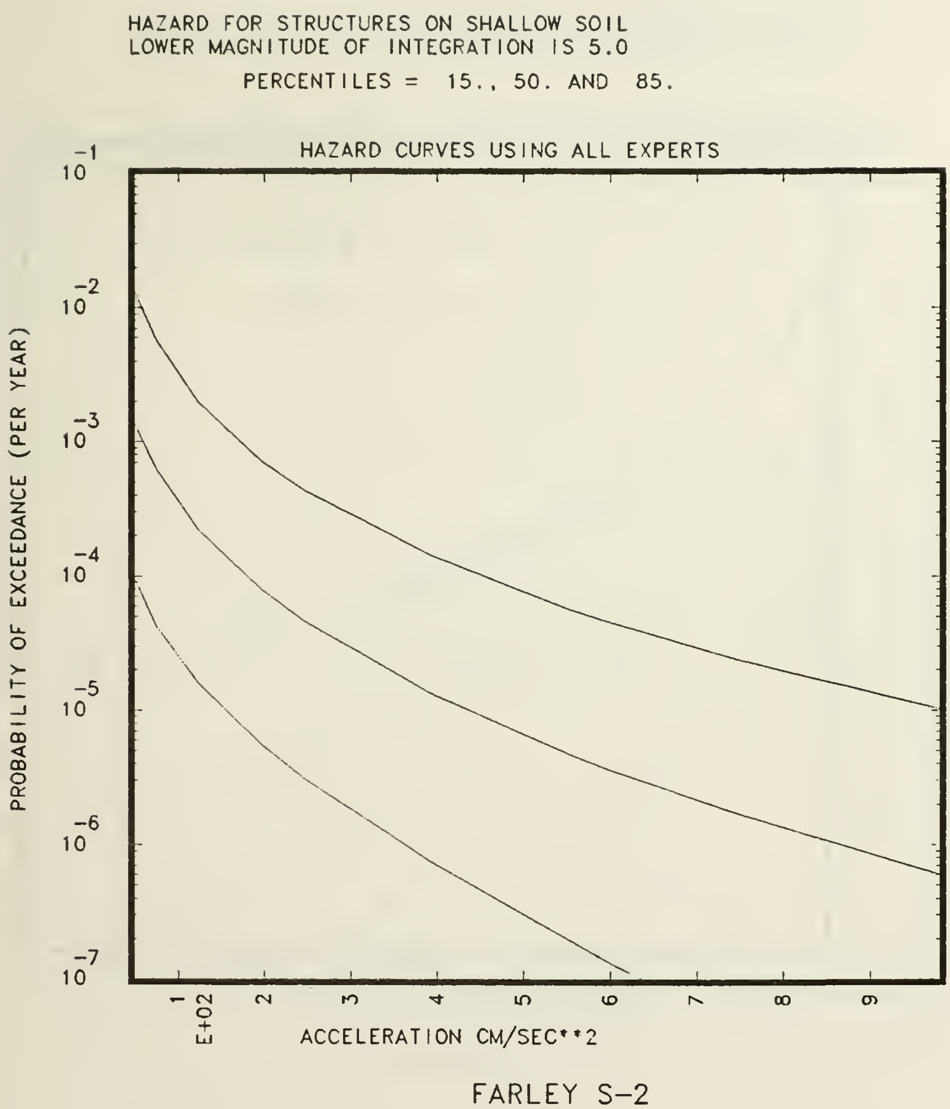
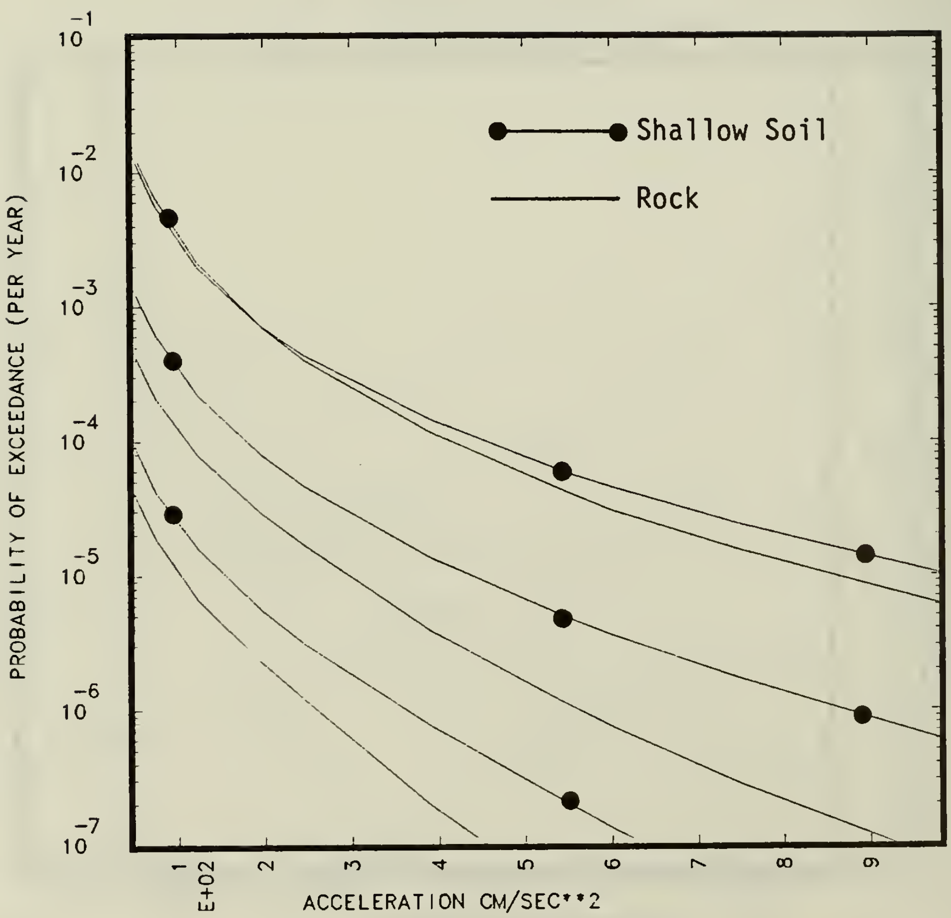


Figure 2.6.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Farley site.

LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.



FARLEY S-2

Figure 2.6.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Farley site.

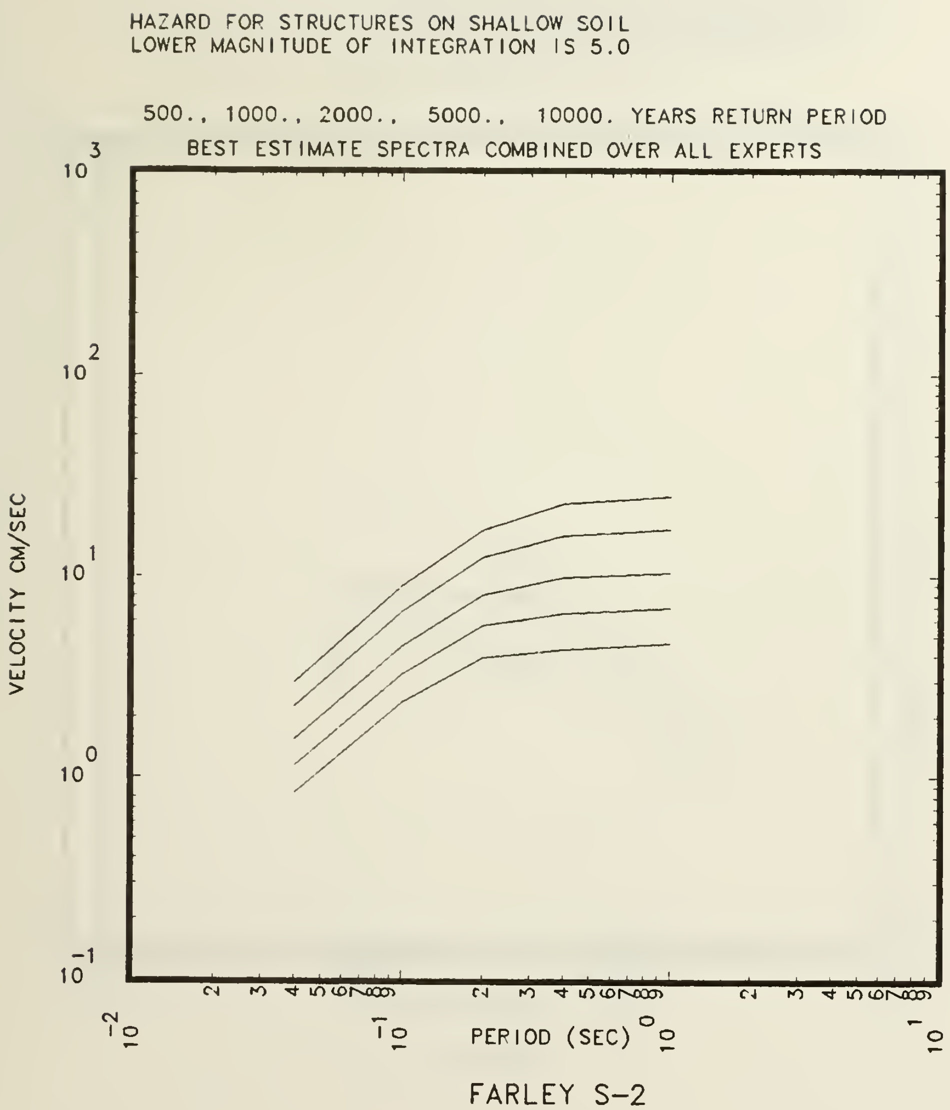


Figure 2.6.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Farley site.

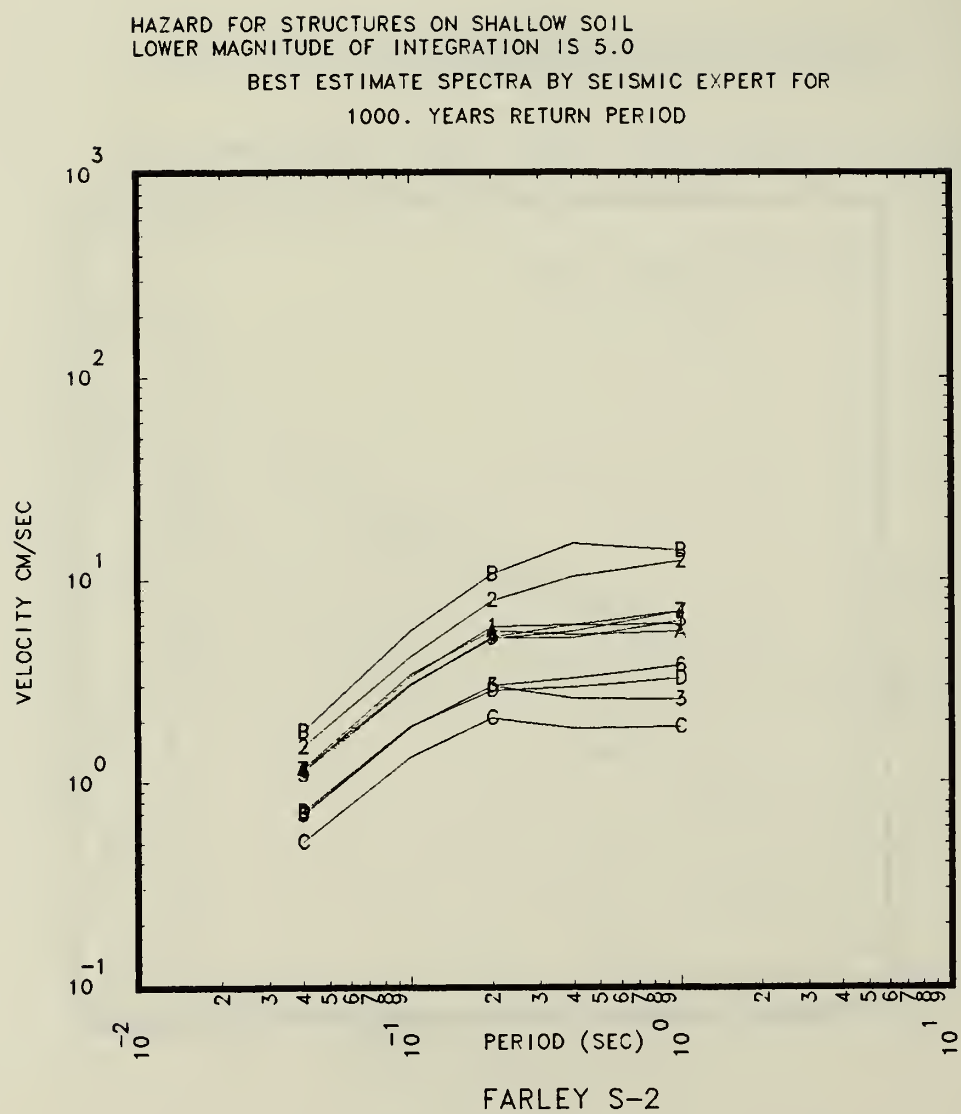


Figure 2.6.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Farley site. Plot symbols are given in Table 2.0

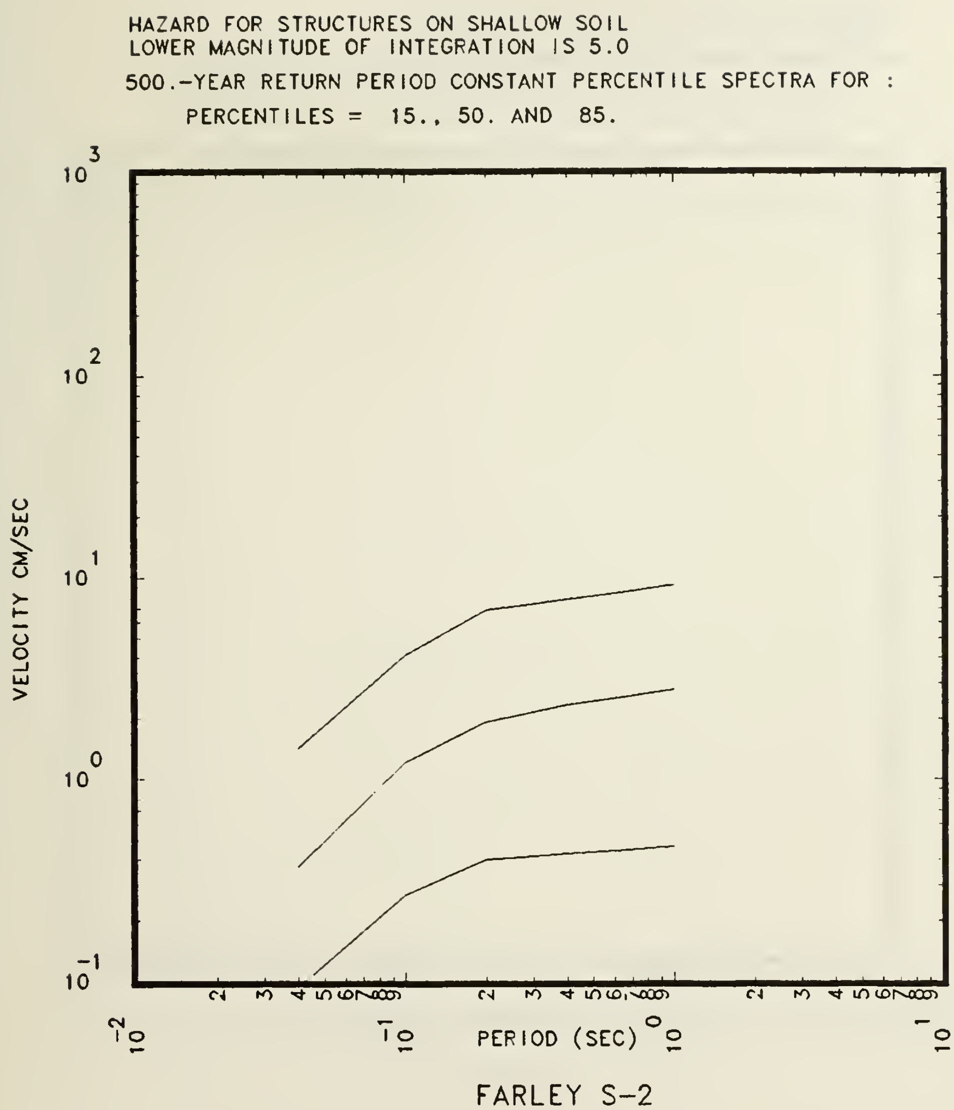


Figure 2.6.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Farley site.

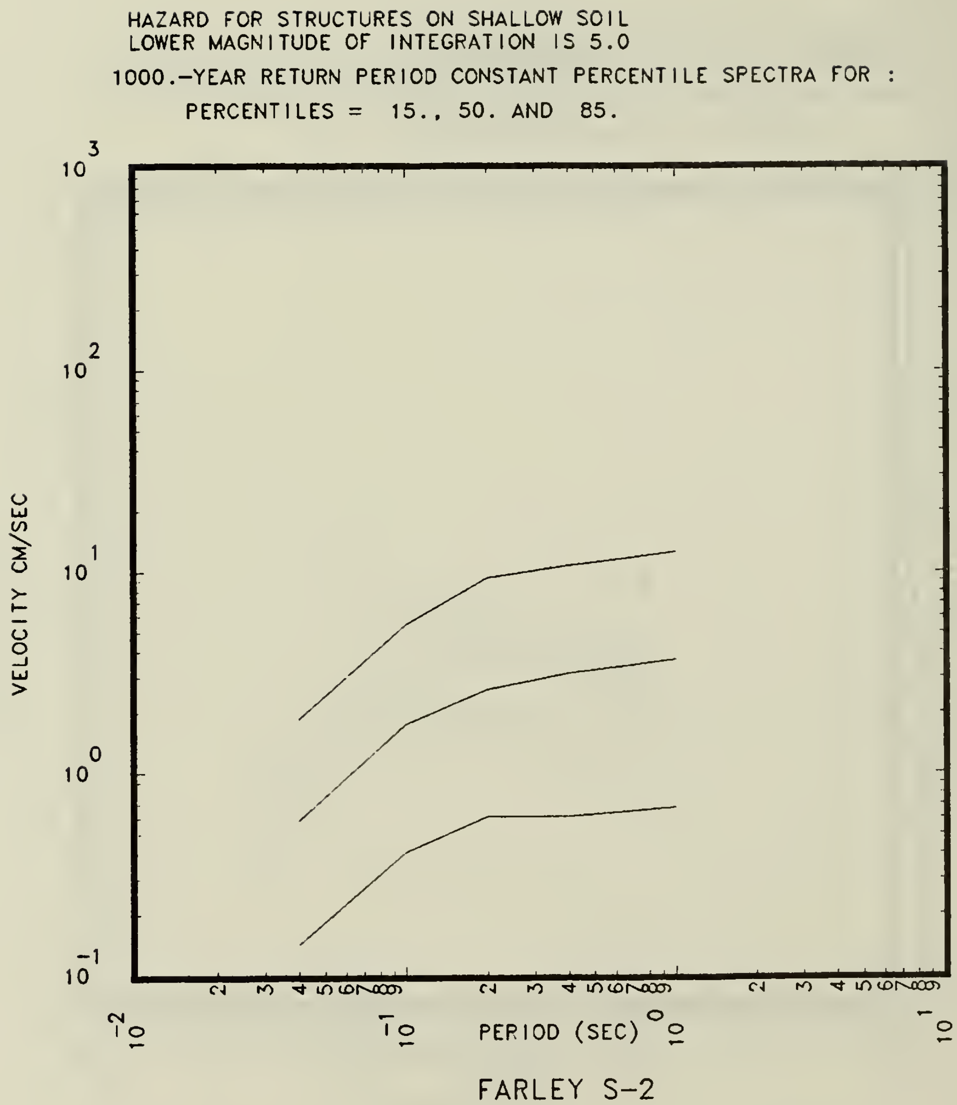


Figure 2.6.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Farley site.

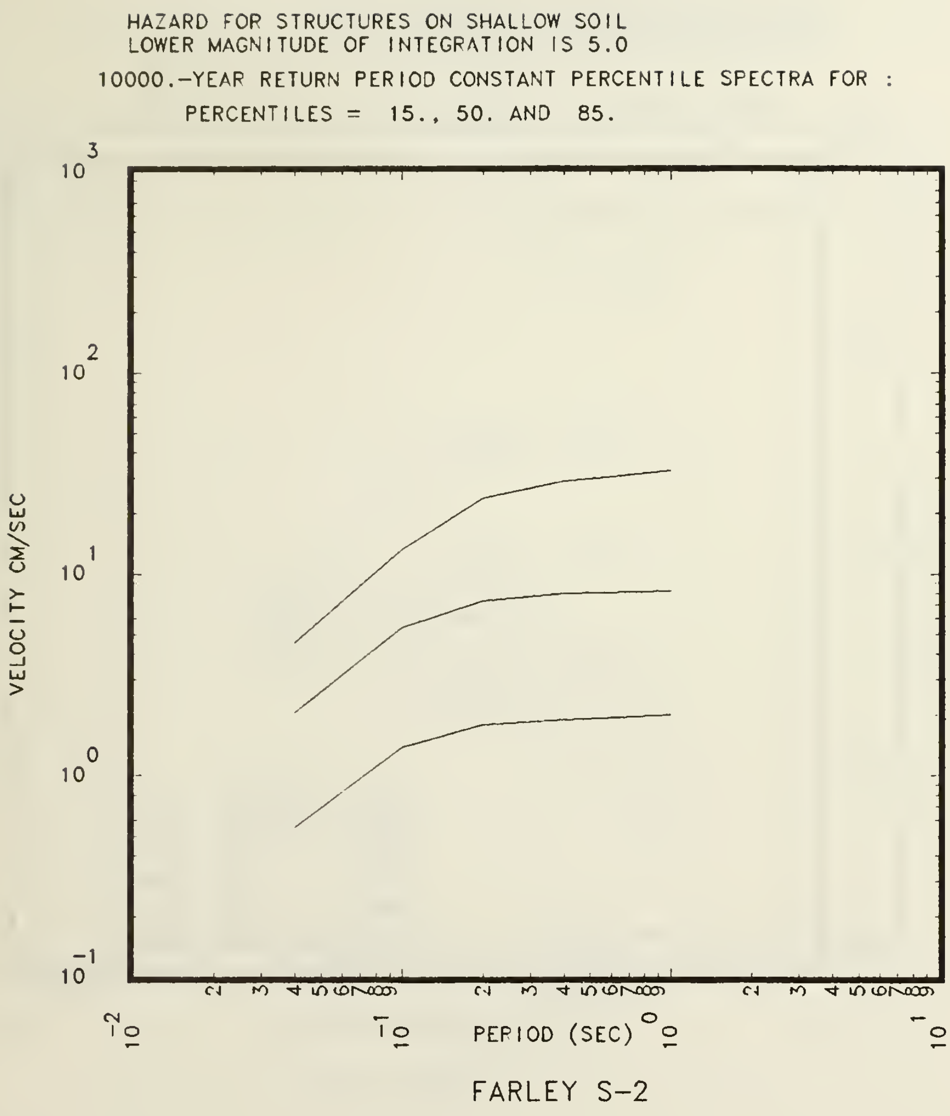
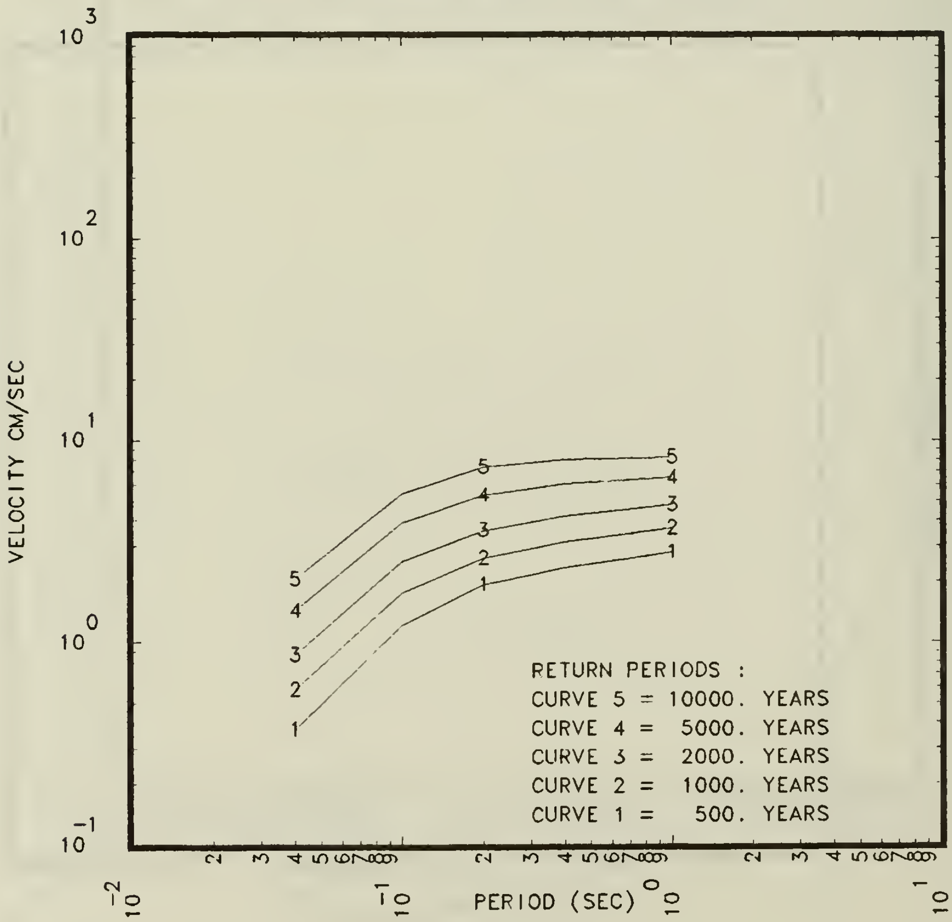


Figure 2.6.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Farley site.

HAZARD FOR STRUCTURES ON SHALLOW SOIL
LOWER MAGNITUDE OF INTEGRATION IS 5.0

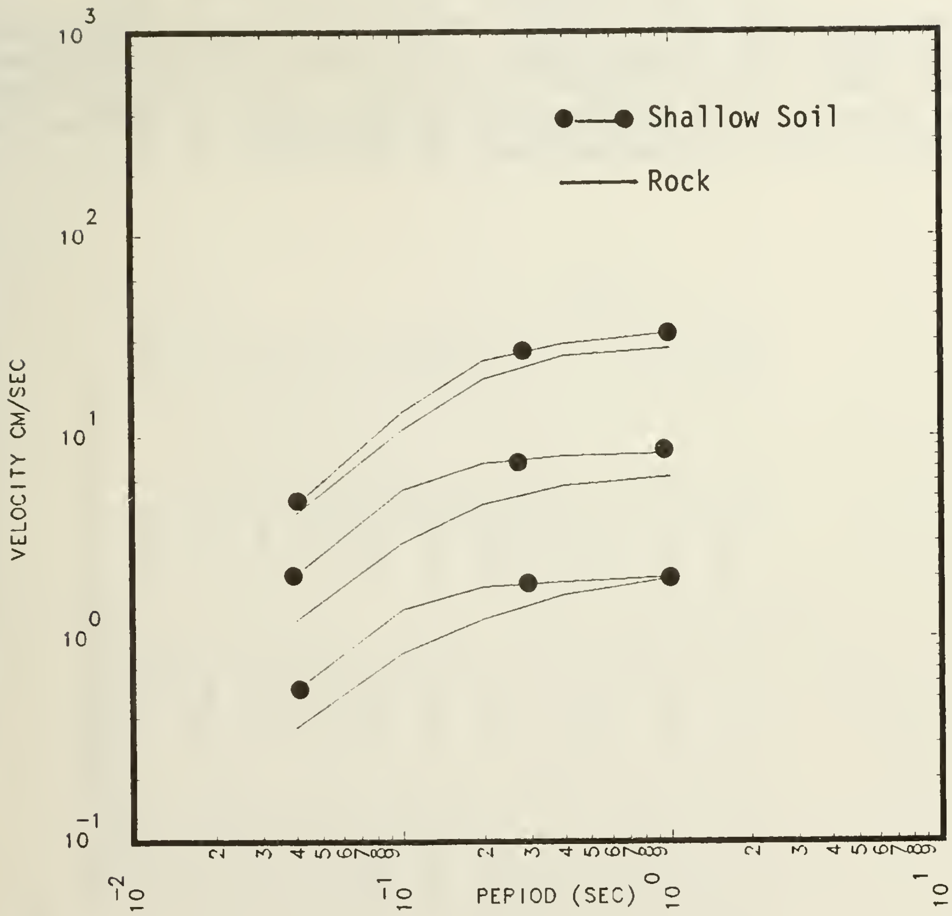
50-TH PERCENTILE SPECTRA FOR ALL RETURN PERIODS



FARLEY S-2

Figure 2.6.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Farley site.

LOWER MAGNITUDE OF INTEGRATION IS 5.0
10000.-YEAR RETURN PERIOD CONSTANT PERCENTILE SPECTRA FOR :
PERCENTILES = 15., 50. AND 85.



FARLEY S-2

Figure 2.6.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Farley site.

2.7 North Anna

The location of the North Anna site is shown in Fig. 1.1 by the plot symbol "7". Most of the structures at the North Anna site are founded on rock. The hazard results for the rock case are given in Section 2.9 of Vol. III. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the North Anna site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.7.1 and Figs. 2.7.1 to 2.7.11 give the basic results most applicable to the structures founded on shallow soil at the North Anna site.

We noted in Section 2.9 of Vol. III that for the rock case the zones nearby the sites contributed most to the hazard. Thus there are no significant changes between Table 2.7.1 and Table 2.9.1 of Vol. III. Thus, as might be expected, the differences in the CPHCs and CPUHS between the rock and Sand-1 cases are similar to the differences found in Vol. VI.

TABLE 2.7.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR NORTH ANNA S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 3	ZONE ID:	ZONE 3	ZONE 4	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 1	ZONE 2
		% CONT.:	72.	20.	7.	1.	97.	2.	1.	0.
2	ZONE 27	ZONE ID:	ZONE 27	ZONE 30	ZONE 28	COMP. ZON	ZONE 27	ZONE 30	COMP. ZON	ZONE 28
		% CONT.:	78.	11.	9.	1.	98.	1.	0.	0.
3	ZONE 6	ZONE ID:	ZONE 6	ZONE 5	ZONE 8A	ZONE 9	ZONE 6	ZONE 5	ZONE 8A	COMP. ZON
		% CONT.:	82.	14.	3.	0.	98.	2.	0.	0.
4	ZONE 11	ZONE ID:	ZONE 11	ZONE 8	ZONE 10	ZONE 12	ZONE 11	ZONE 8	COMP. ZON	ZONE 10
		% CONT.:	45.	40.	6.	4.	91.	9.	0.	0.
5	ZONE 1	ZONE ID:	ZONE 1	ZONE 9	ZONE 10	ZONE 8	ZONE 1	ZONE 9	ZONE 8	ZONE 10
		% CONT.:	69.	16.	6.	5.	99.	1.	0.	0.
6	ZONE 15	ZONE ID:	ZONE 15	ZONE 13	ZONE 6	ZONE 11	ZONE 15	ZONE 13	ZONE 6	ZONE 11
		% CONT.:	90.	4.	3.	2.	99.	1.	0.	0.
7	ZONE 9	ZONE ID:	ZONE 9	ZONE 7	ZONE 29	ZONE 10	ZONE 9	ZONE 7	ZONE 29	ZONE 10
		% CONT.:	65.	23.	10.	2.	89.	8.	3.	0.
10	ZONE 4B	ZONE ID:	ZONE 4B	ZONE 5	ZONE 28A	ZONE 19 =	ZONE 4B	ZONE 5	ZONE 19 =	ZONE 1
		% CONT.:	66.	30.	2.	1.	98.	1.	1.	0.
11	ZONE 7	ZONE ID:	ZONE 7	ZONE 5	ZONE 6	CZ = ZONE	ZONE 7	ZONE 5	ZONE 8	ZONE 6
		% CONT.:	57.	23.	8.	6.	85.	10.	3.	1.
12	ZONE 32	ZONE ID:	ZONE 32	ZONE 20	ZONE 22	ZONE 23A	ZONE 32	ZONE 20	ZONE 23A	ZONE 13
		% CONT.:	96.	2.	1.	1.	100.	0.	0.	0.
13	CZ 17	ZONE ID:	CZ 17	CZ 15	ZONE 8	ZONE 9	CZ 17	CZ 15	ZONE 8	ZONE 6
		% CONT.:	85.	7.	7.	1.	98.	1.	0.	0.

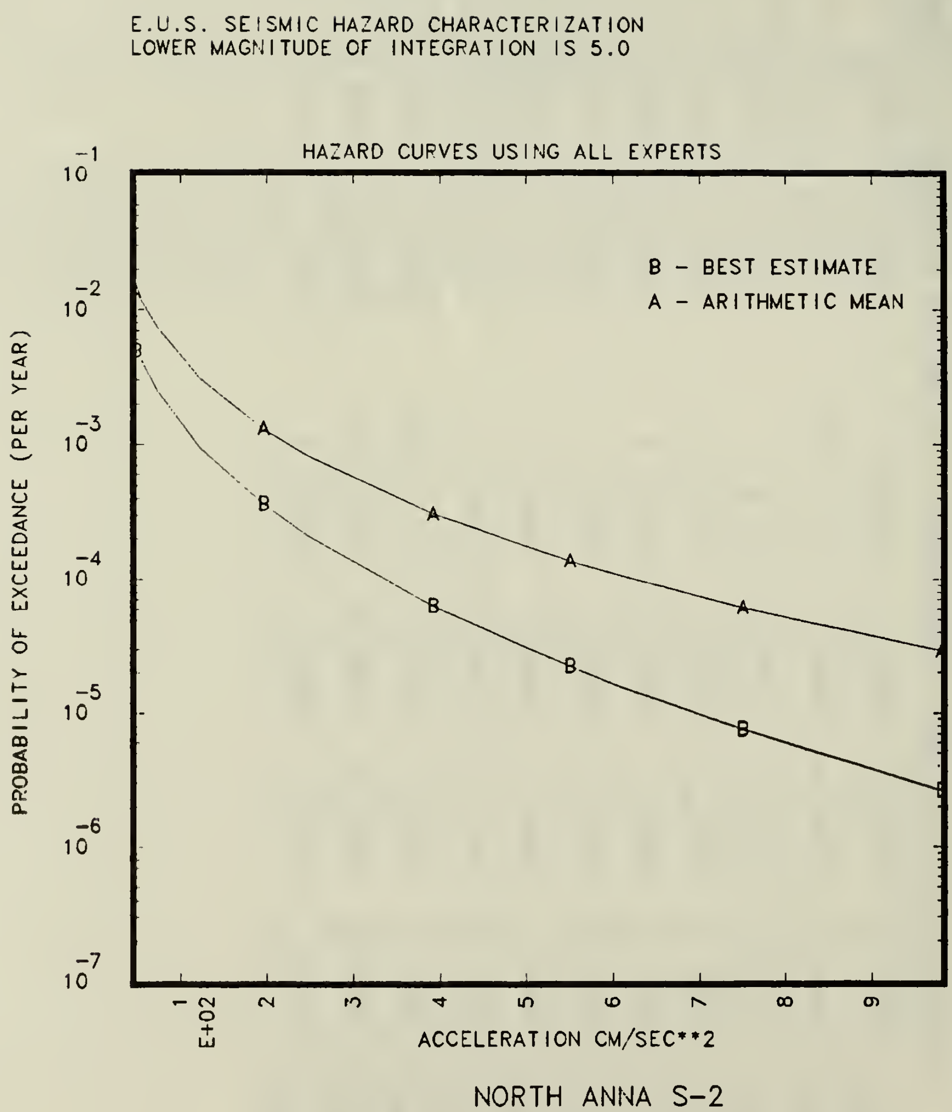


Figure 2.7.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the North Anna site.

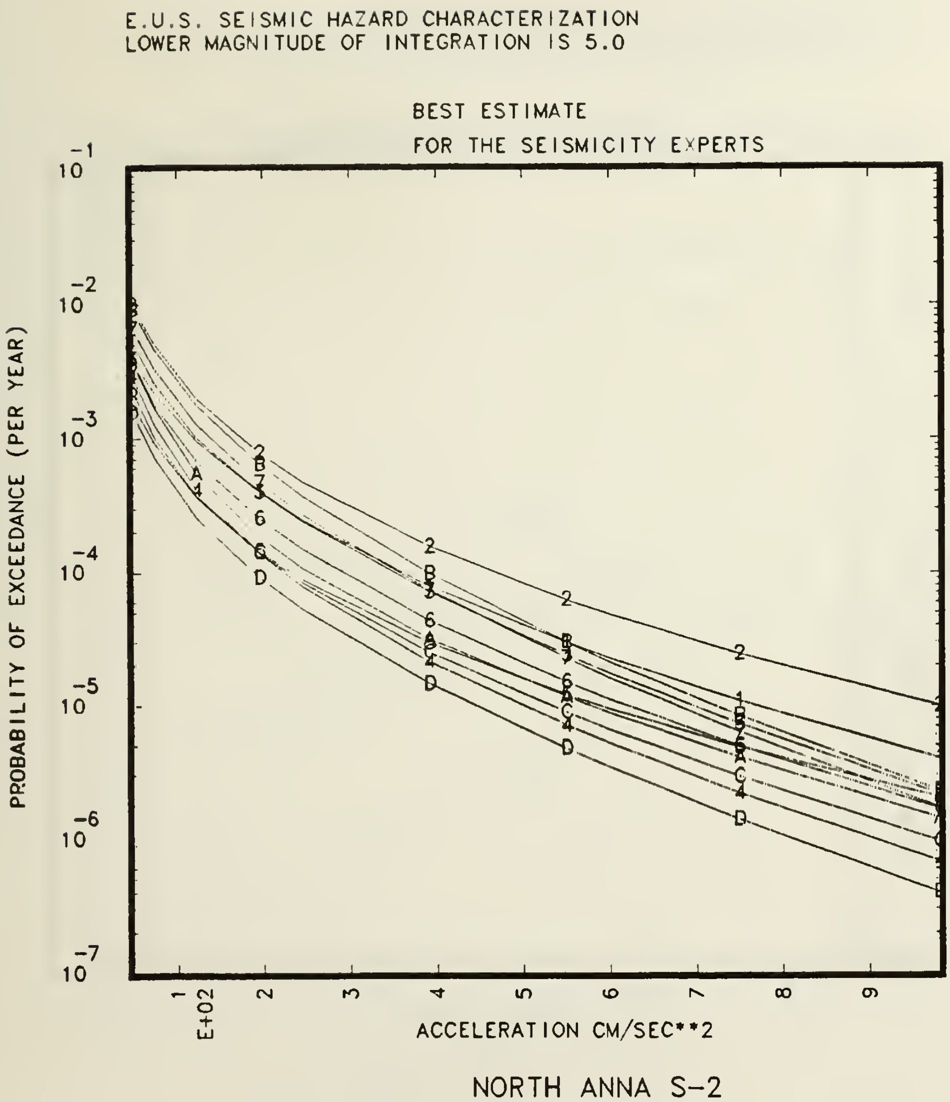


Figure 2.7.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the North Anna site. Plot symbols given in Table 2.0.

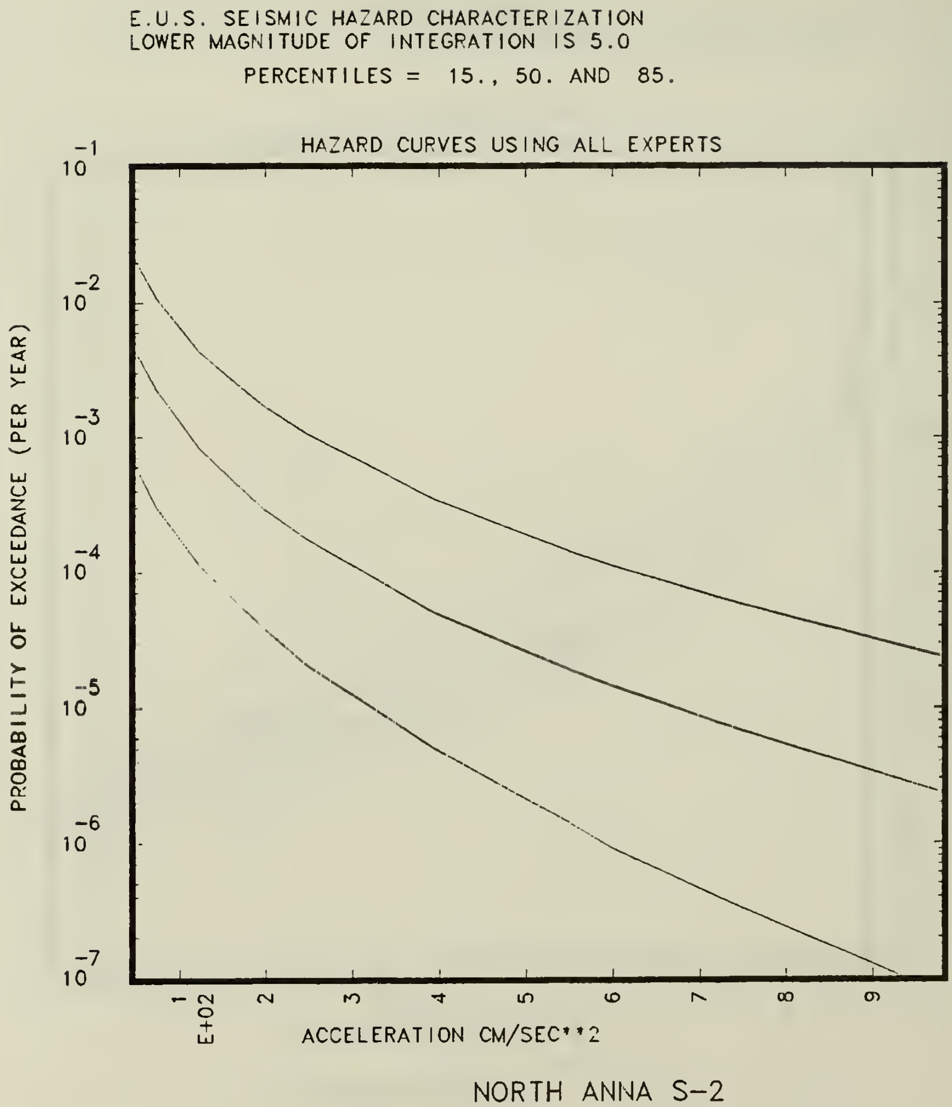


Figure 2.7.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the North Anna site.

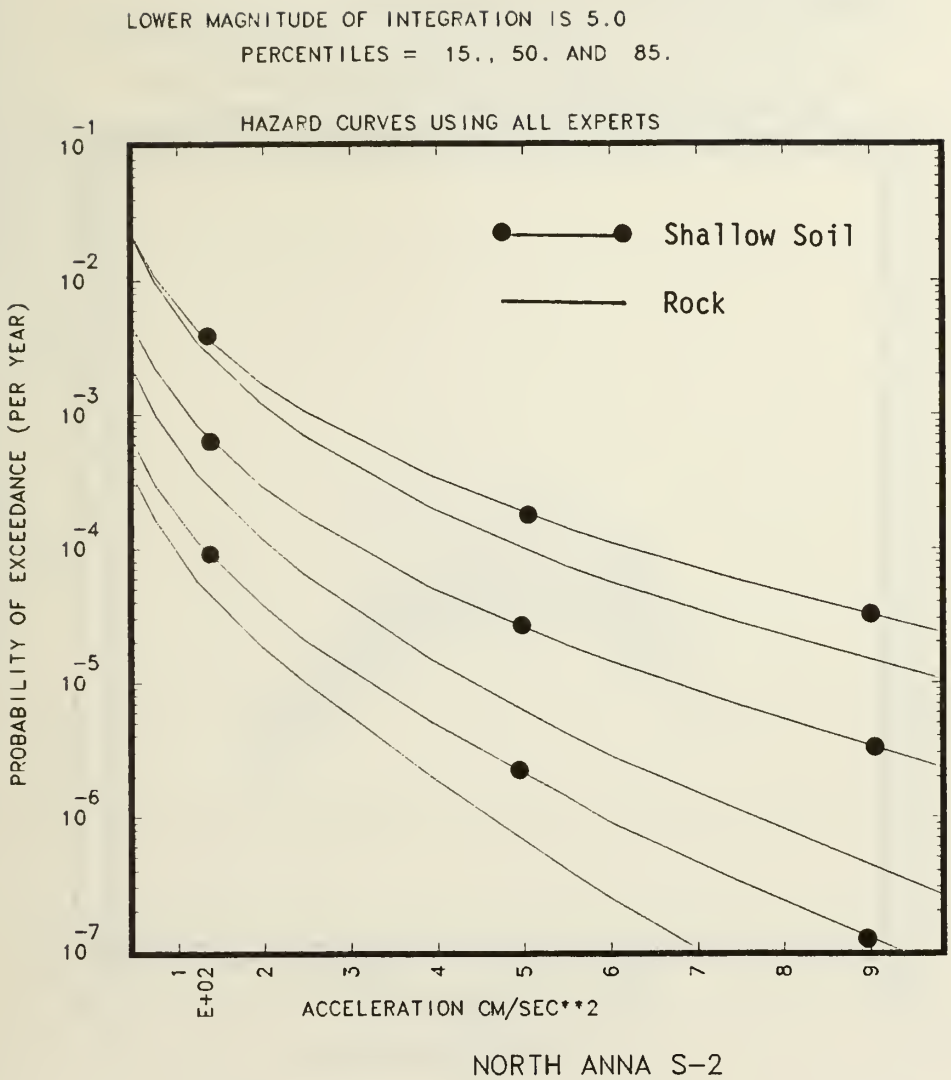


Figure 2.7.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the North Anna site.

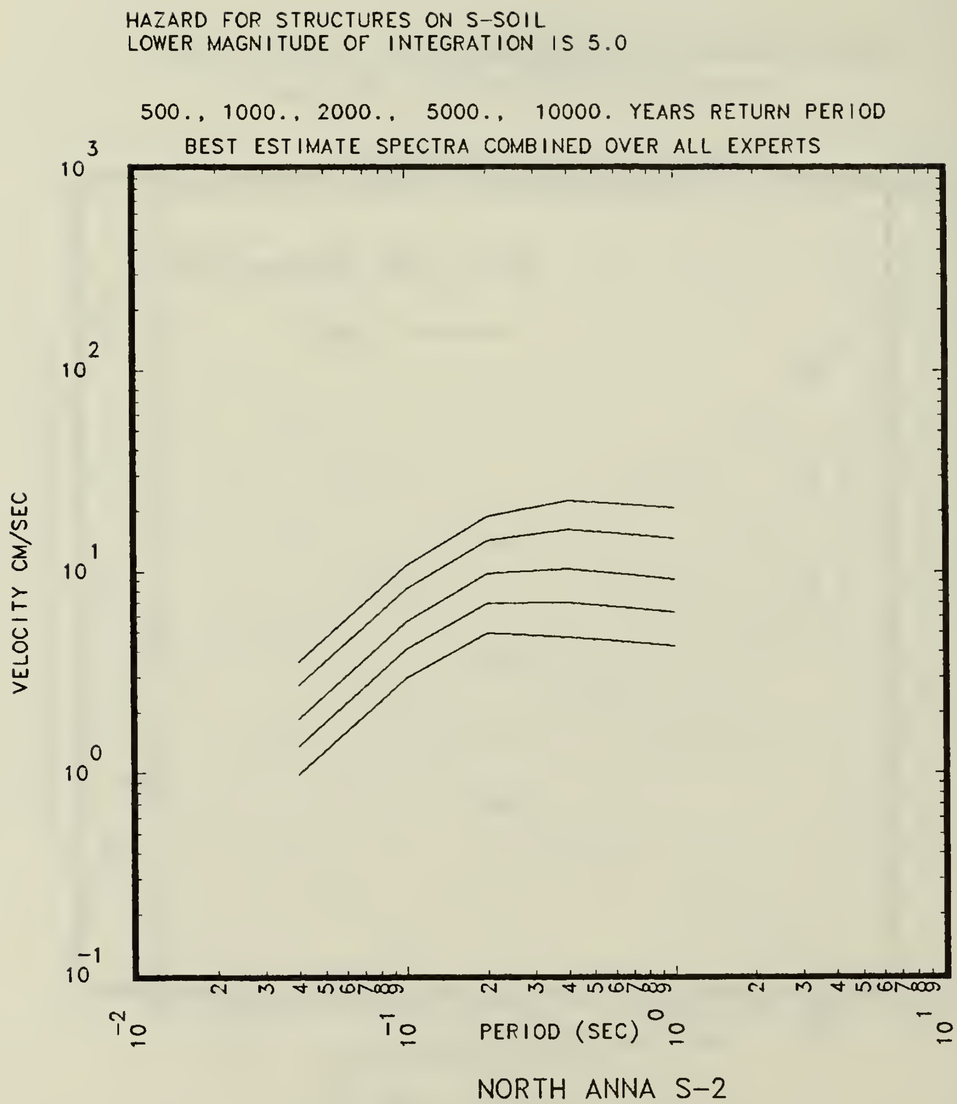


Figure 2.7.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the North Anna site.

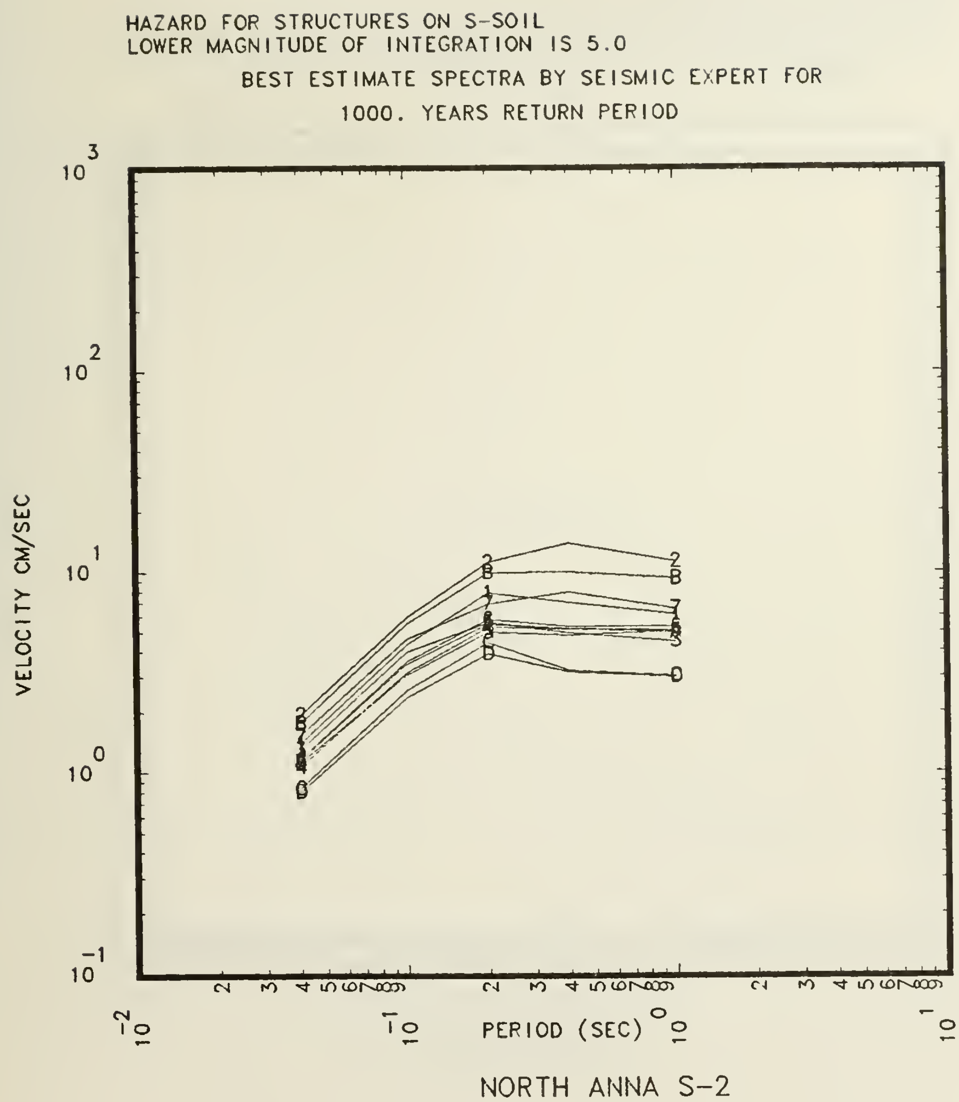


Figure 2.7.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the North Anna site. Plot symbols are given in Table 2.0

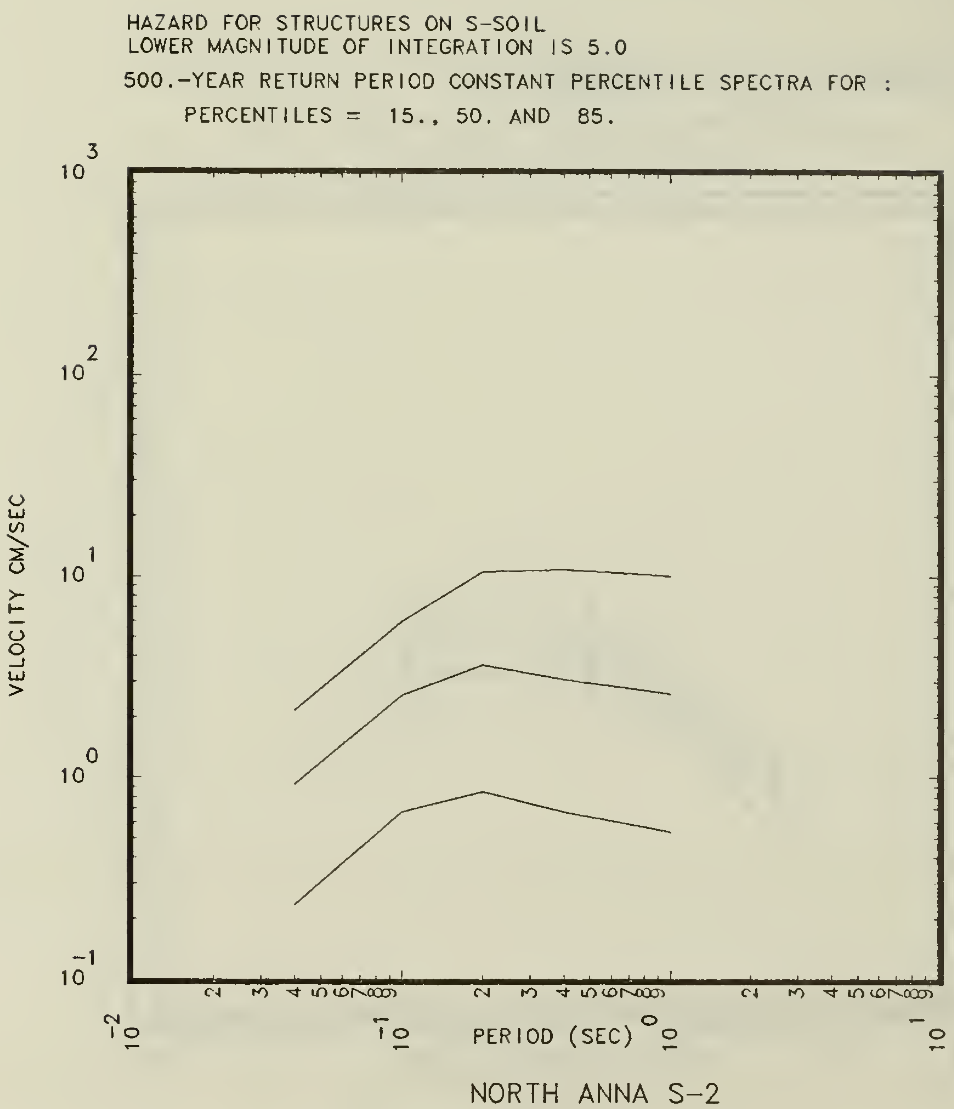


Figure 2.7.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the North Anna site.

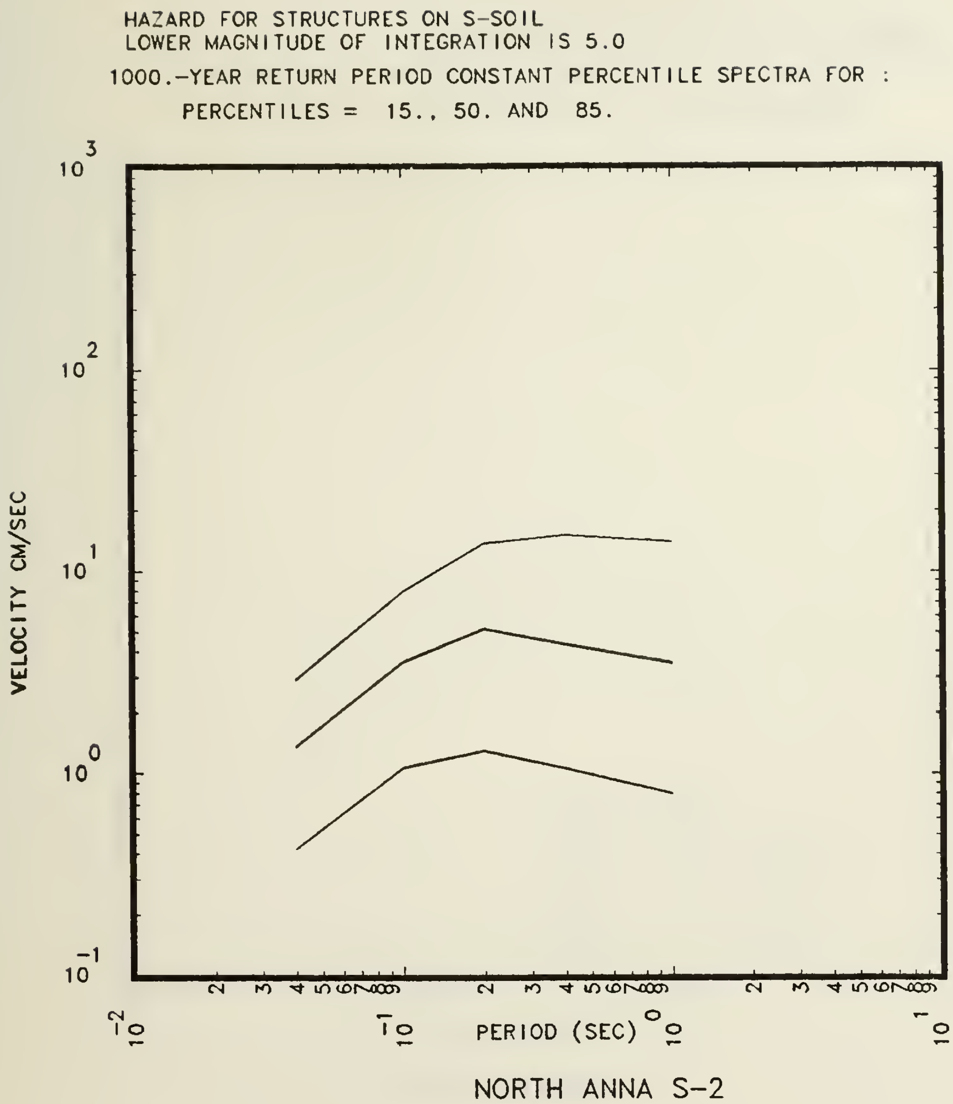


Figure 2.7.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the North Anna site.

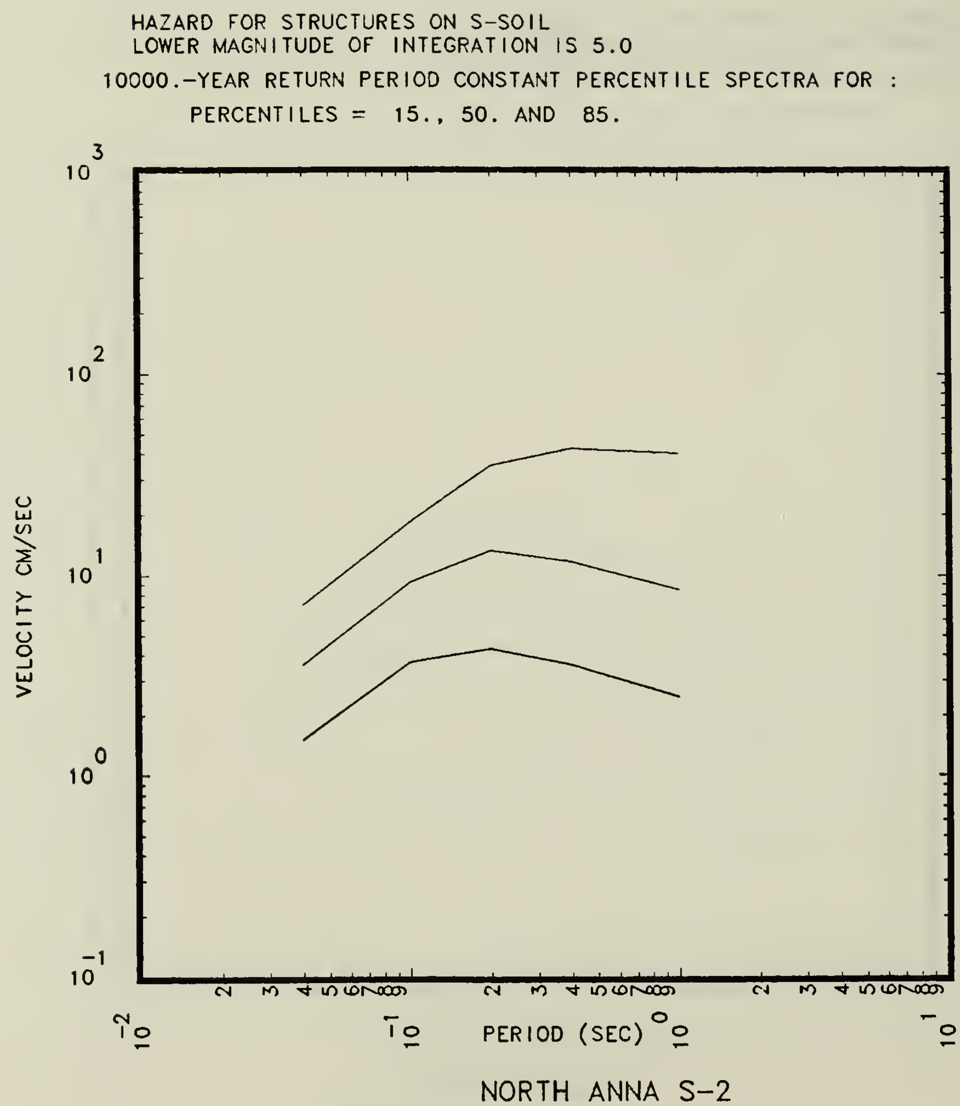


Figure 2.7.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the North Anna site.

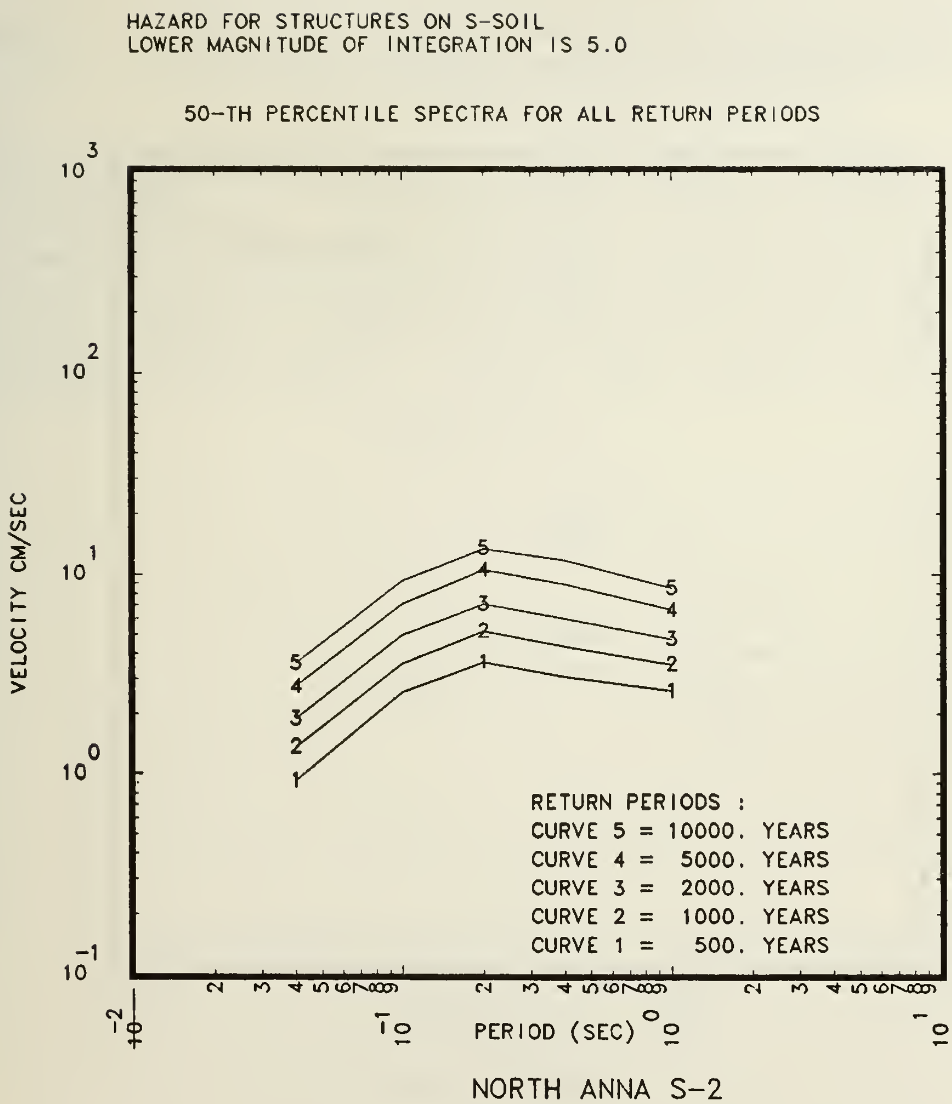


Figure 2.7.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the North Anna site.

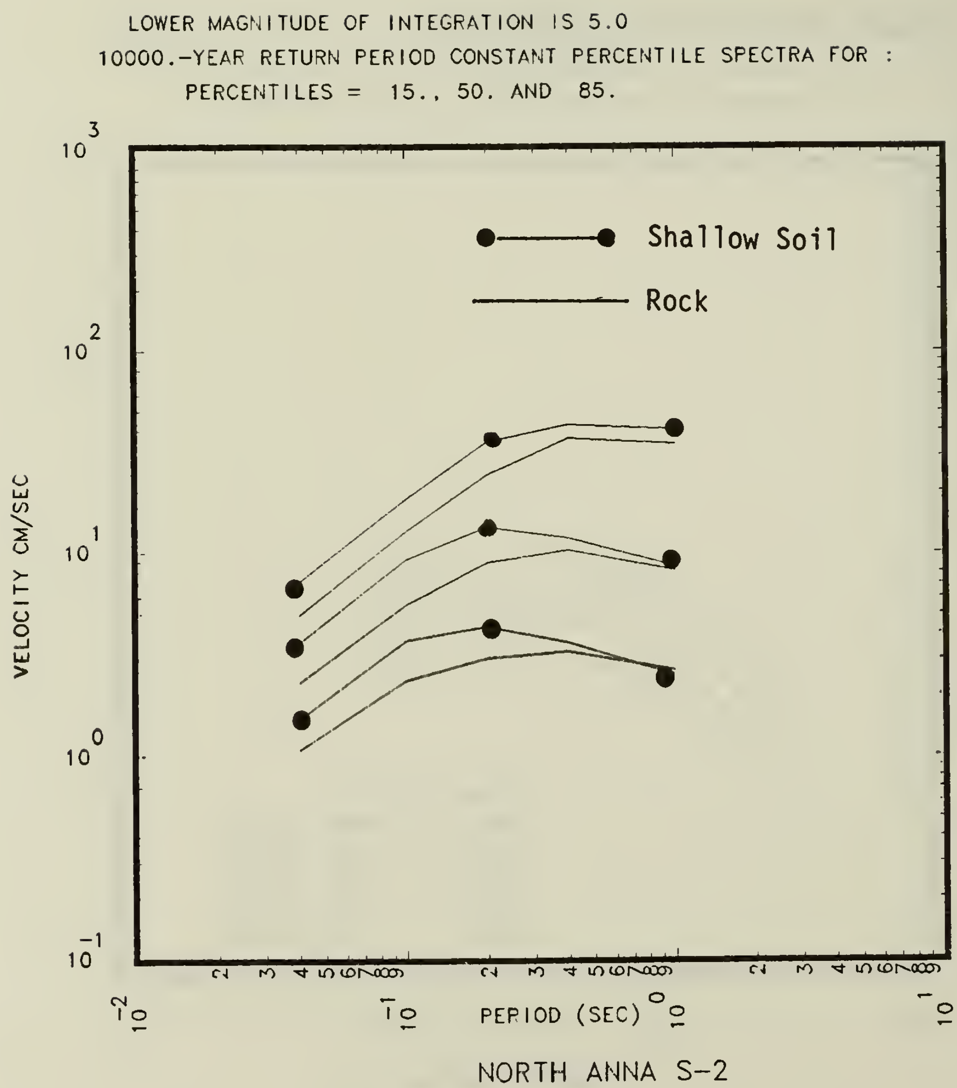


Figure 2.7.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the North Anna site.

2.8 Oconee

The location of the Oconee site is shown in Fig. 1.1 by the plot symbol "8". Most of the structures at the Oconee site are founded on rock. The hazard results for the rock case are given in Section 2.10 of Vol. III. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Oconee site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.10.1 and Figs. 2.10.1 to 2.10.11 give the basic results most applicable to the structures founded on shallow soil at the Oconee site.

If Table 2.8.1 is compared to Table 2.10.1 in Vol. III, we see a number of significant changes. For the rock case for a number of S-Experts, zones other than the host zone made a larger contribution to BEHC for PGA than the host zone. However, for the soil case, as could be expected based on our previous discussions, the host zone makes the largest contribution to the BEHC for PGA. We see from Figs. 2.8.4 and 2.8.11 that the differences in the CPHCs and CPUHS between the rock and Sand-1 cases are only slightly higher than would be expected based on the sensitivity results given in Section 2.2 of Vol. VI.

TABLE 2.8.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR OCONEE S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 3	ZONE ID:	ZONE 3	ZONE 4	ZONE 9	ZONE 2	ZONE 3	ZONE 4	ZONE 9	ZONE 2
		% CONT.:	53.	28.	12.	5.	86.	8.	6.	0.
2	ZONE 27	ZONE ID:	ZONE 27	ZONE 30	ZONE 29	ZONE 18	ZONE 27	ZONE 30	ZONE 29	ZONE 18
		% CONT.:	35.	30.	18.	16.	63.	15.	12.	10.
3	ZONE 7	ZONE ID:	ZONE 7	ZONE 5	ZONE 9	ZONE 13	ZONE 7	ZONE 5	ZONE 9	ZONE 13
		% CONT.:	53.	40.	4.	1.	89.	10.	0.	0.
4	ZONE 9	ZONE ID:	ZONE 9	ZONE 28	ZONE 10	ZONE 4	ZONE 9	ZONE 28	ZONE 4	ZONE 10
		% CONT.:	50.	24.	14.	10.	89.	6.	2.	2.
5	ZONE 11	ZONE ID:	ZONE 11	ZONE 9	ZONE 10	ZONE 15	ZONE 11	ZONE 10	ZONE 9	ZONE 15
		% CONT.:	44.	29.	18.	9.	69.	14.	13.	5.
6	ZONE 11	ZONE ID:	ZONE 11	ZONE 10	ZONE 9	ZONE 8	ZONE 11	ZONE 10	ZONE 9	ZONE 1
		% CONT.:	84.	12.	4.	0.	94.	6.	0.	0.
7	ZONE 8	ZONE ID:	ZONE 7	ZONE 8	ZONE 6	ZONE 10	ZONE 8	ZONE 7	ZONE 6	ZONE 10
		% CONT.:	33.	30.	26.	10.	58.	24.	14.	4.
10	ZONE 28	ZONE ID:	ZONE 28	ZONE 15	ZONE 12A	ZONE 28A	ZONE 28	ZONE 19 =	ZONE 15	ZONE 4B
		% CONT.:	96.	2.	1.	1.	100.	0.	0.	0.
11	ZONE 7	ZONE ID:	ZONE 7	ZONE 8	ZONE 6	CZ = ZONE	ZONE 7	ZONE 8	CZ = ZONE	ZONE 6
		% CONT.:	73.	12.	9.	5.	94.	5.	1.	1.
12	ZONE 21	ZONE ID:	ZONE 20	ZONE 21	ZONE 19	ZONE 23A	ZONE 21	ZONE 20	ZONE 19	ZONE 23A
		% CONT.:	39.	28.	24.	6.	61.	36.	2.	2.
13	CZ 17	ZONE ID:	ZONE 8	CZ 17	ZONE 9	ZONE 5	CZ 17	ZONE 8	ZONE 9	ZONE 5
		% CONT.:	60.	29.	6.	5.	61.	37.	1.	1.

HAZARD FOR STRUCTURES ON SHALLOW SOIL
LOWER MAGNITUDE OF INTEGRATION IS 5.0

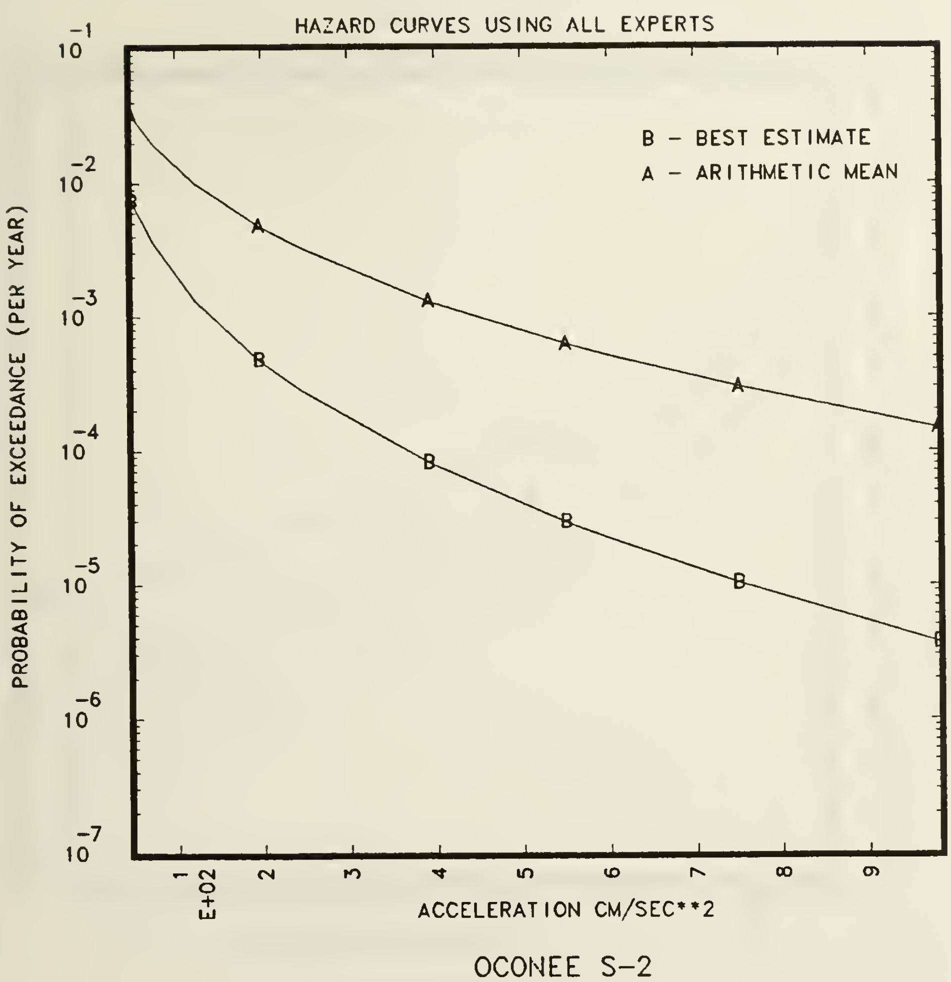


Figure 2.8.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Oconee site.

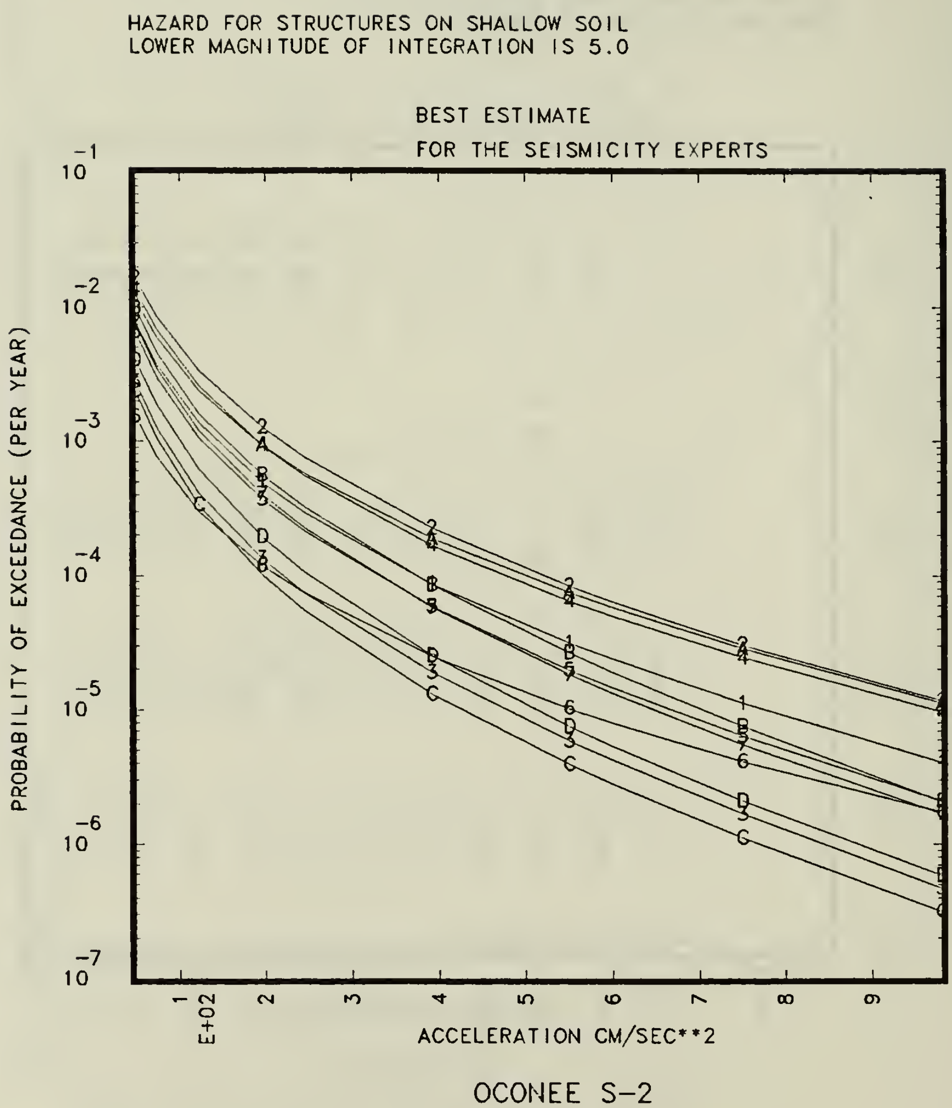
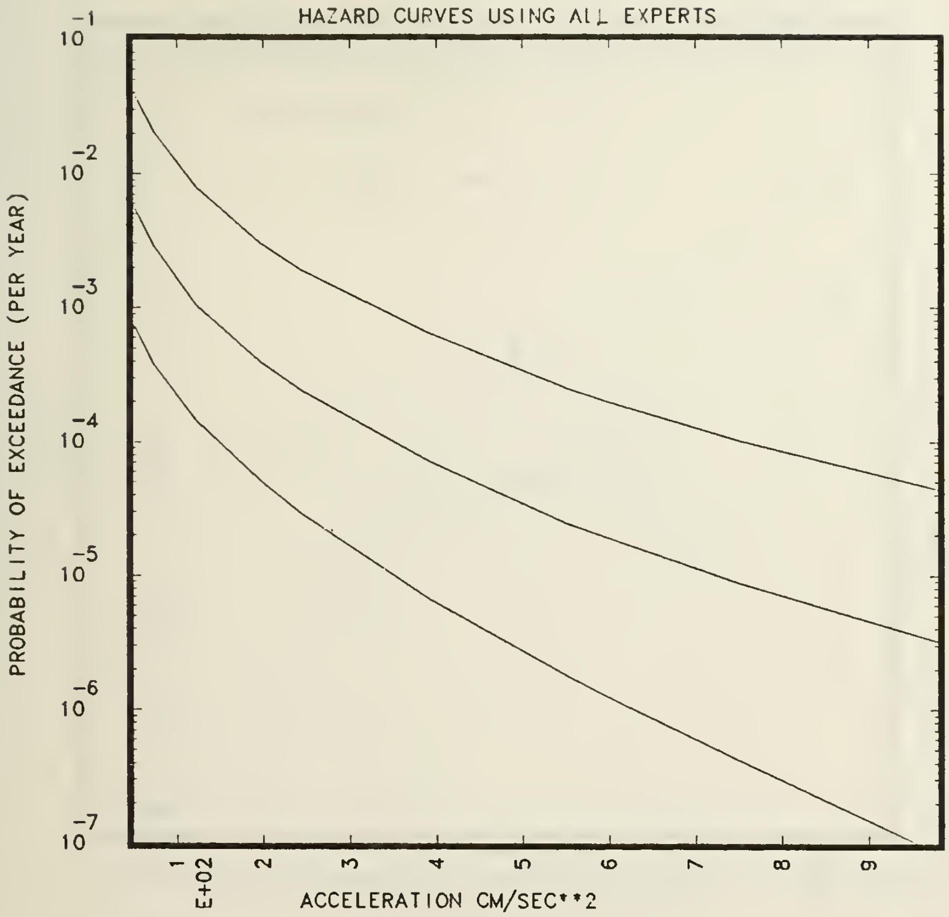


Figure 2.8.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Oconee site. Plot symbols given in Table 2.0.

HAZARD FOR STRUCTURES ON SHALLOW SOIL
LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.



OCONEE S-2

Figure 2.8.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Oconee site.

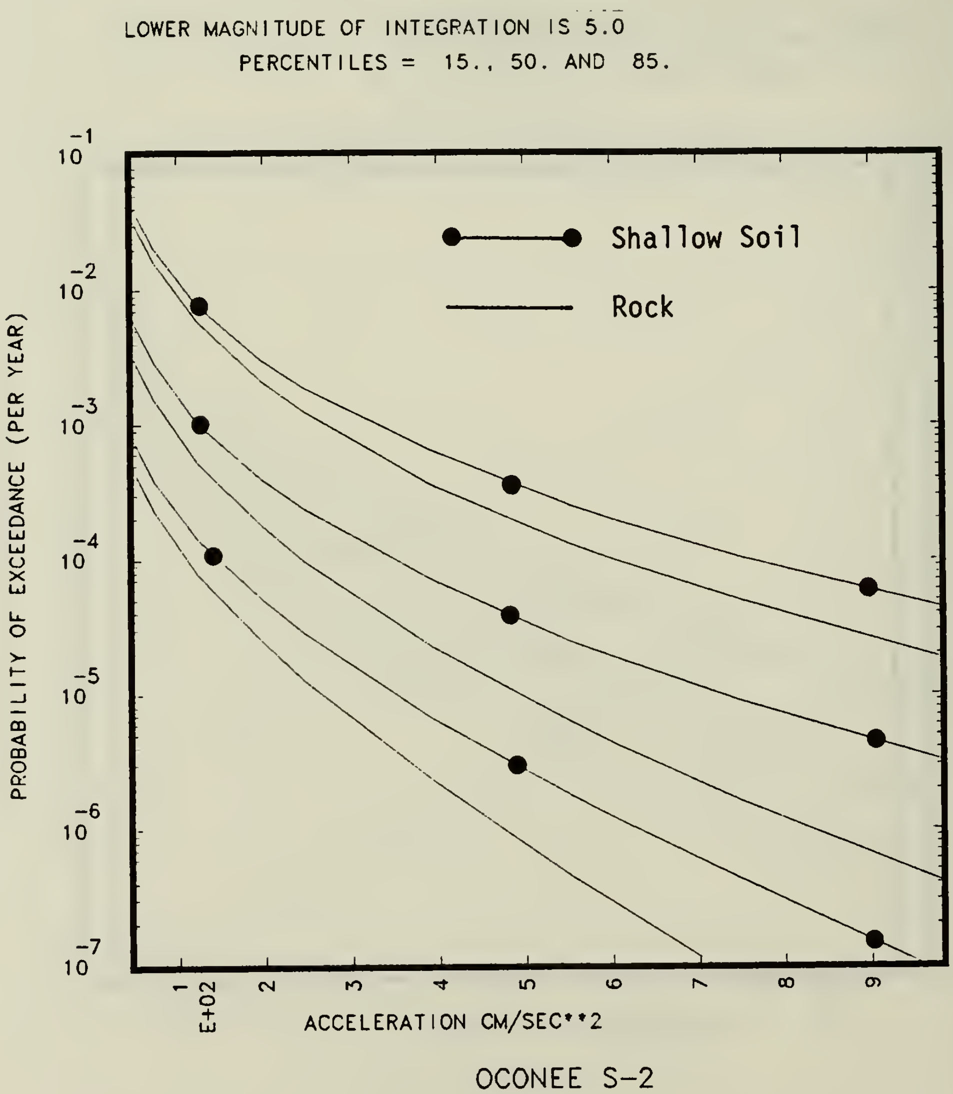


Figure 2.8.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Oconee site.

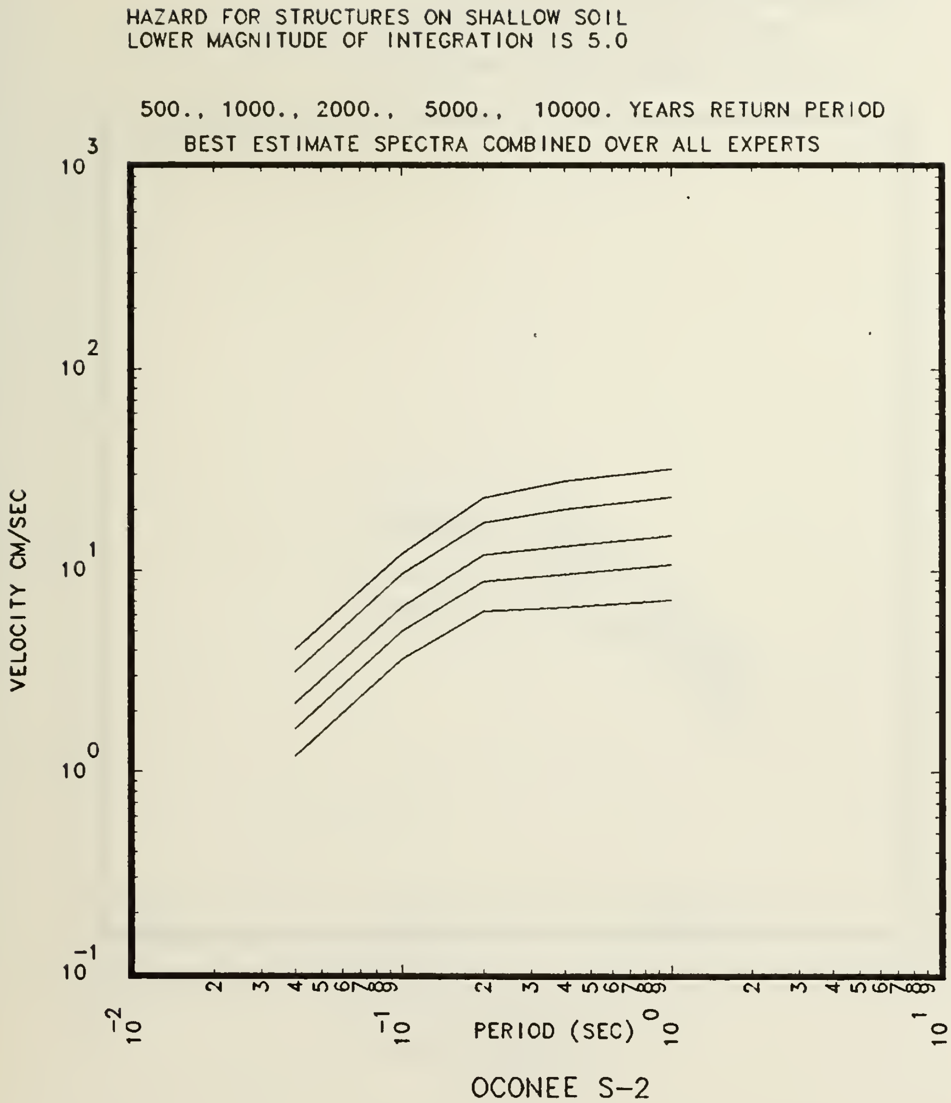


Figure 2.8.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Oconee site.

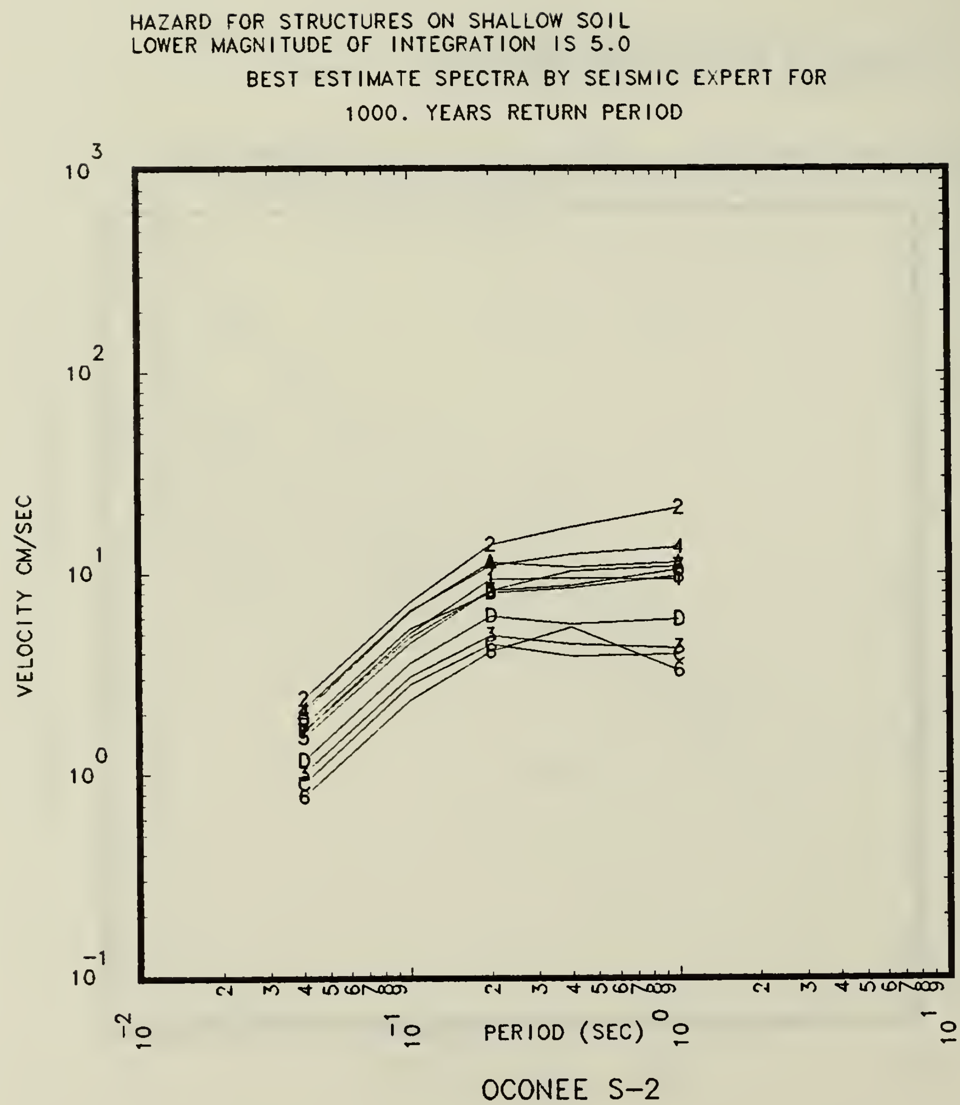


Figure 2.8.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Oconee site. Plot symbols are given in Table 2.0

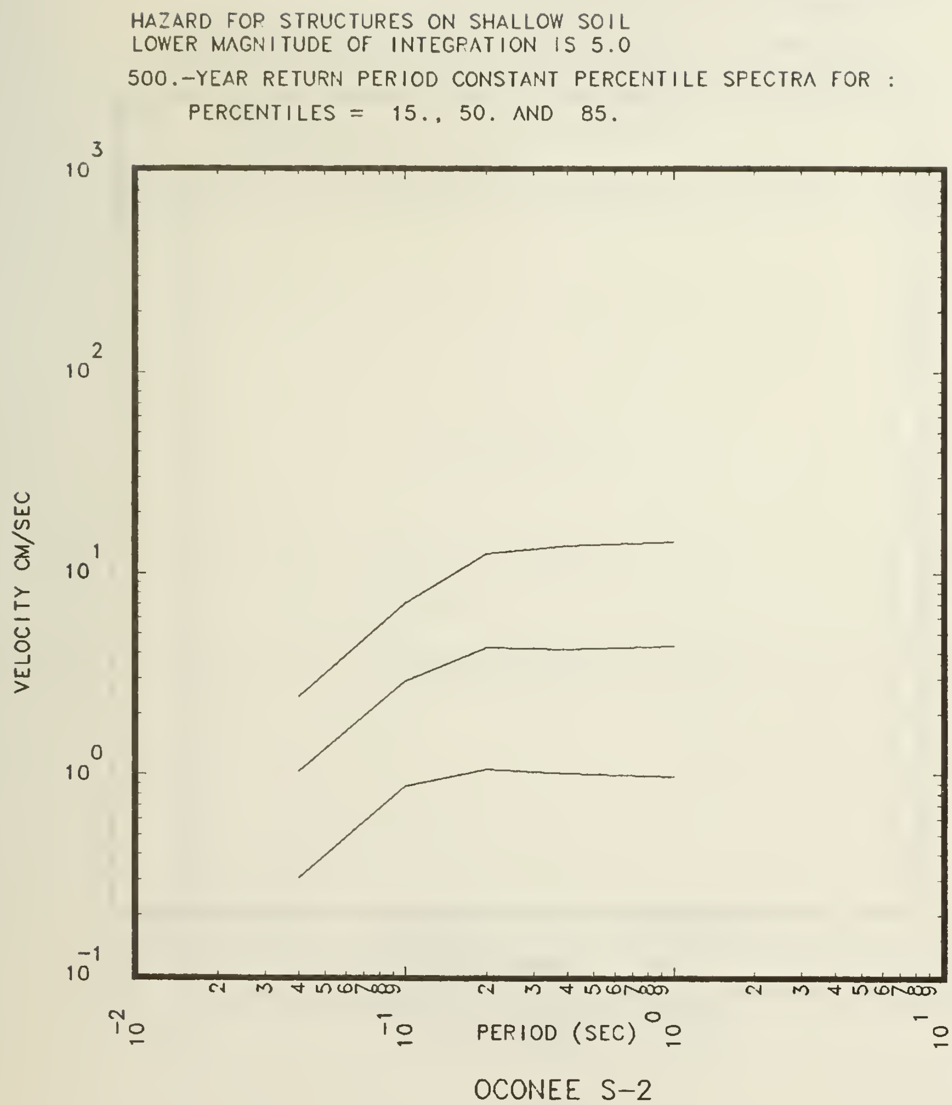


Figure 2.8.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Oconee site.

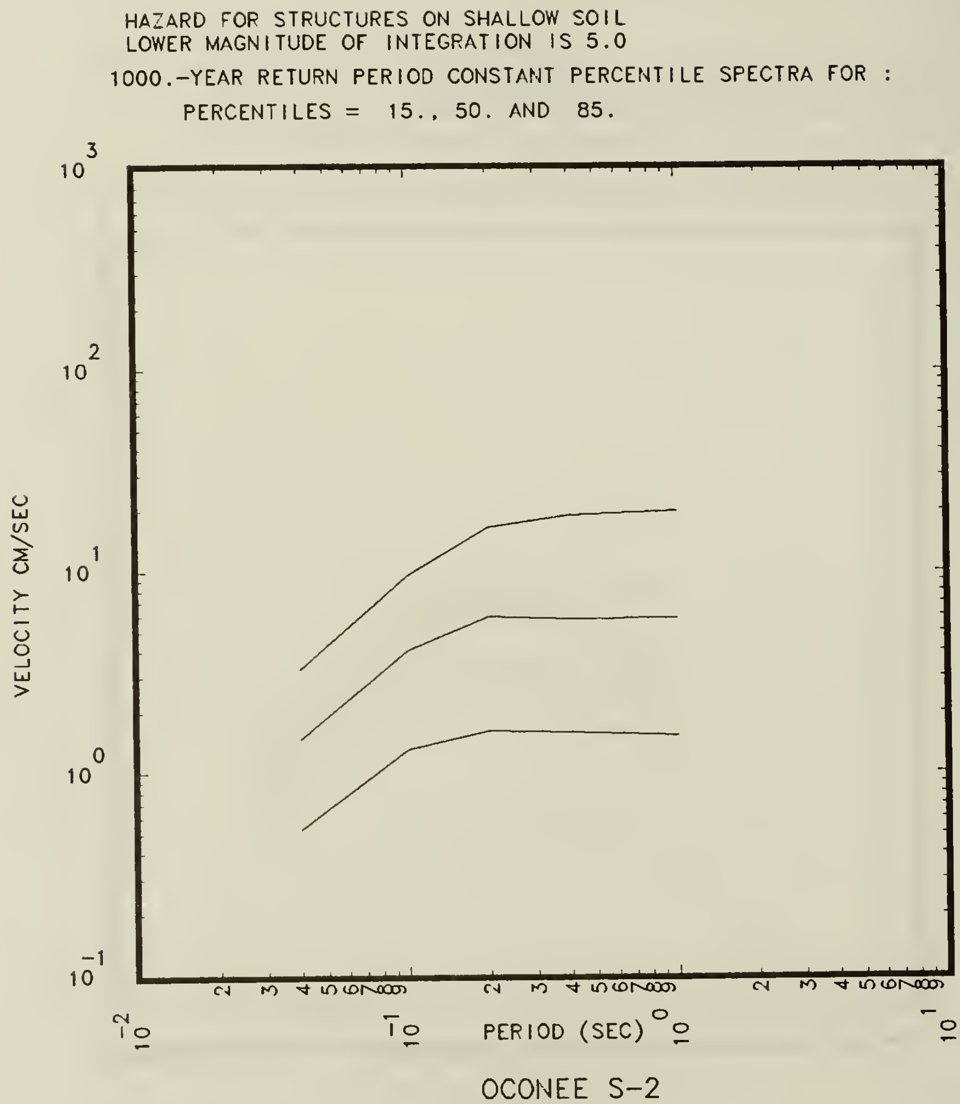


Figure 2.8.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Oconee site.

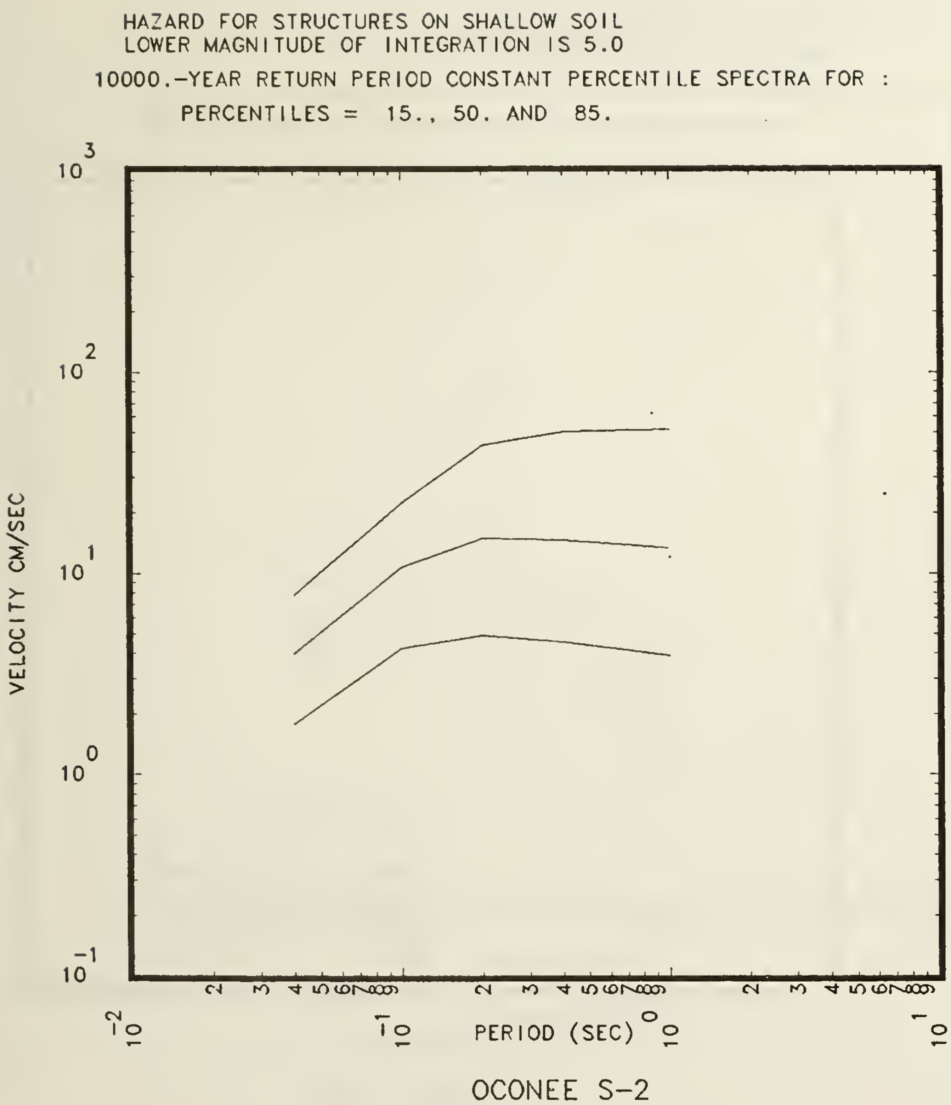


Figure 2.8.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Oconee site.

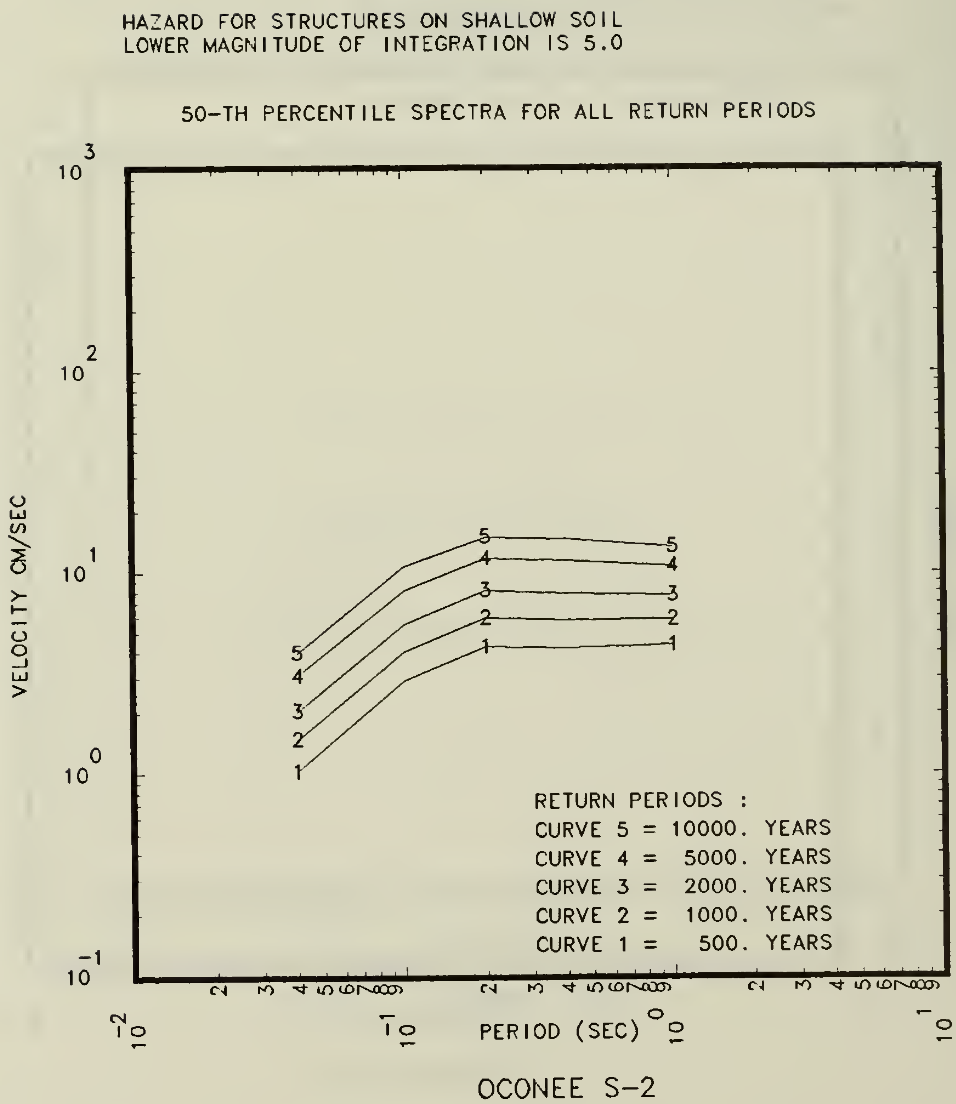


Figure 2.8.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Oconee site.

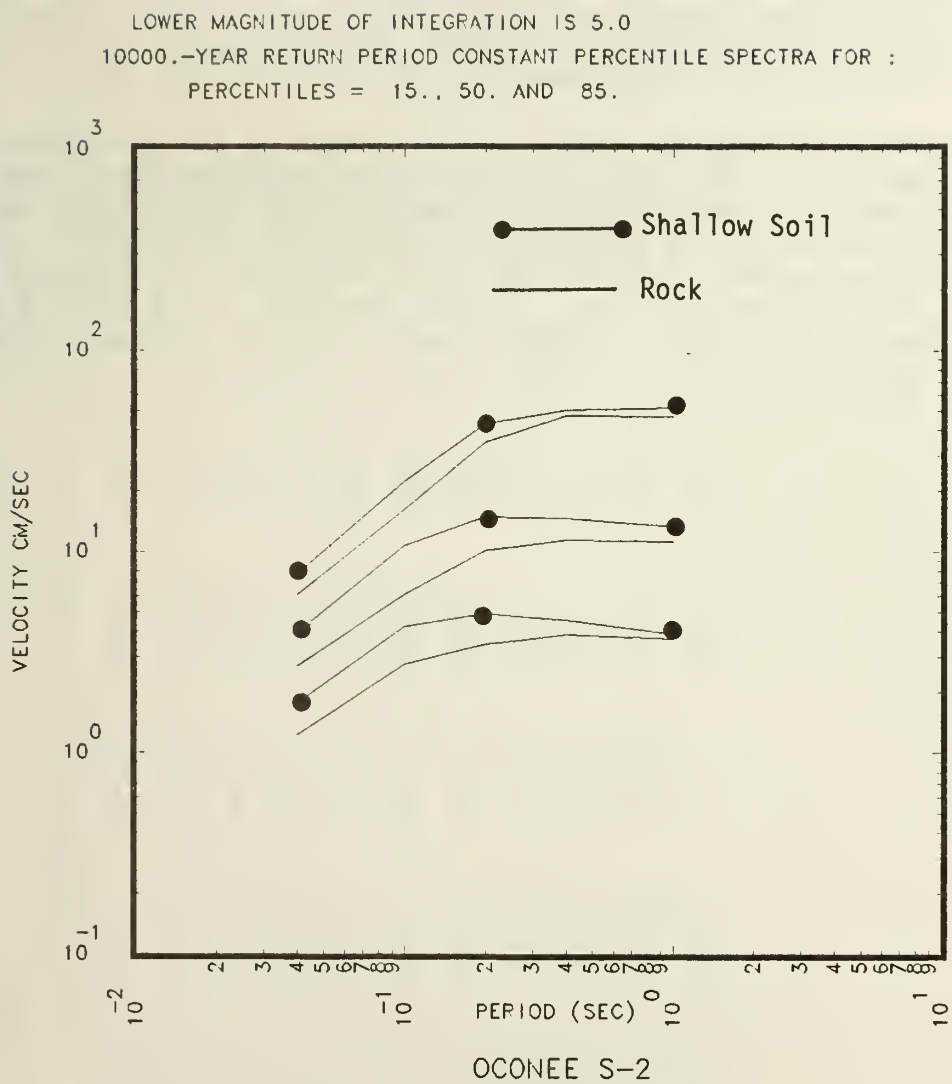


Figure 2.8.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Oconee site.

2.9 Summer

The location of the Summer site is shown in Fig. 1.1 by the plot symbol "9". Most of the structures at the Summer site are founded on rock. The hazard results for the rock case are given in Section 2.14 of Vol. II. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Summer site was considered to be best represented by our Sand-1 soil category described in Section 3.7 of Vol. I. Table 2.9.1 and Figs. 2.9.1 to 2.9.11 give the basic results most applicable to the structures founded on shallow soil at the Summer site.

We see from Fig. 1.1 that the Summer site is closer to the Charleston region than the Oconee site. Thus, for the Summer site, the Charleston zones remain, for most S-Experts, the most important zones for both the rock and shallow soil cases as can be seen by comparing Table 2.9.1 to Table 2.14.1 of Vol. III. We see however, that in Table 2.9.1 the local zones become more significant than for the rock case. We see from Figs. 2.9.4 and 2.9.11 that the differences in the CPHCs and CPUHS between the rock and Sand-1 cases are higher than would be expected from the sensitivity results given in Section 2.2 of Vol. VI.

TABLE 2.9.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR SUMMER S-2

SITE SOIL CATEGORY SAND-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 3	ZONE ID:	ZONE 3	ZONE 2	ZONE 1	ZONE 9	ZONE 3	ZONE 2	ZONE 1	ZONE 9
		% CONT.:	57.	32.	5.	5.	89.	9.	1.	1.
2	ZONE 29	ZONE ID:	ZONE 30	ZONE 29	ZONE 18	ZONE 27	ZONE 30	ZONE 29	ZONE 18	COMP. ZON
		% CONT.:	63.	30.	5.	2.	59.	40.	1.	0.
3	ZONE 7	ZONE ID:	ZONE 7	ZONE 9	ZONE 5	ZONE 8	ZONE 7	ZONE 9	COMP. ZON	ZONE 8
		% CONT.:	58.	38.	2.	2.	91.	9.	0.	0.
4	ZONE 9	ZONE ID:	ZONE 10	ZONE 9	ZONE 4	ZONE 28	ZONE 10	ZONE 9	ZONE 4	ZONE 2
		% CONT.:	71.	27.	2.	0.	53.	46.	0.	0.
5	ZONE 10	ZONE ID:	ZONE 9	ZONE 10	ZONE 15	ZONE 11	ZONE 9	ZONE 10	ZONE 15	ZONE 11
		% CONT.:	76.	21.	2.	1.	71.	28.	1.	0.
6	ZONE 13	ZONE ID:	ZONE 13	ZONE 11	ZONE 17	ZONE 18	ZONE 13	ZONE 11	COMP. ZON	ZONE 6
		% CONT.:	97.	2.	0.	0.	100.	0.	0.	0.
7	ZONE 8	ZONE ID:	ZONE 10	ZONE 8	ZONE 6	ZONE 7	ZONE 8	ZONE 10	ZONE 6	ZONE 2 =
		% CONT.:	44.	43.	11.	2.	66.	32.	3.	0.
10	ZONE 4B	ZONE ID:	ZONE 28	ZONE 4B	ZONE 15	ZONE 28A	ZONE 4B	ZONE 28	ZONE 15	ZONE 19 =
		% CONT.:	52.	25.	22.	1.	65.	30.	4.	1.
11	ZONE 7	ZONE ID:	ZONE 7	ZONE 8	ZONE 6	ZONE 11	ZONE 7	ZONE 8	CZ = ZONE	ZONE 6
		% CONT.:	68.	30.	1.	0.	64.	35.	1.	0.
12	ZONE 22	ZONE ID:	ZONE 22	ZONE 23A	ZONE 23	ZONE 20	ZONE 22	ZONE 23A	ZONE 23	ZONE 20
		% CONT.:	47.	38.	5.	4.	74.	26.	0.	0.
13	CZ 17	ZONE ID:	ZONE 9	CZ 17	ZONE 8	ZONE 5	CZ 17	ZONE 9	CZ 15	ZONE 5
		% CONT.:	50.	44.	4.	2.	68.	31.	2.	0.

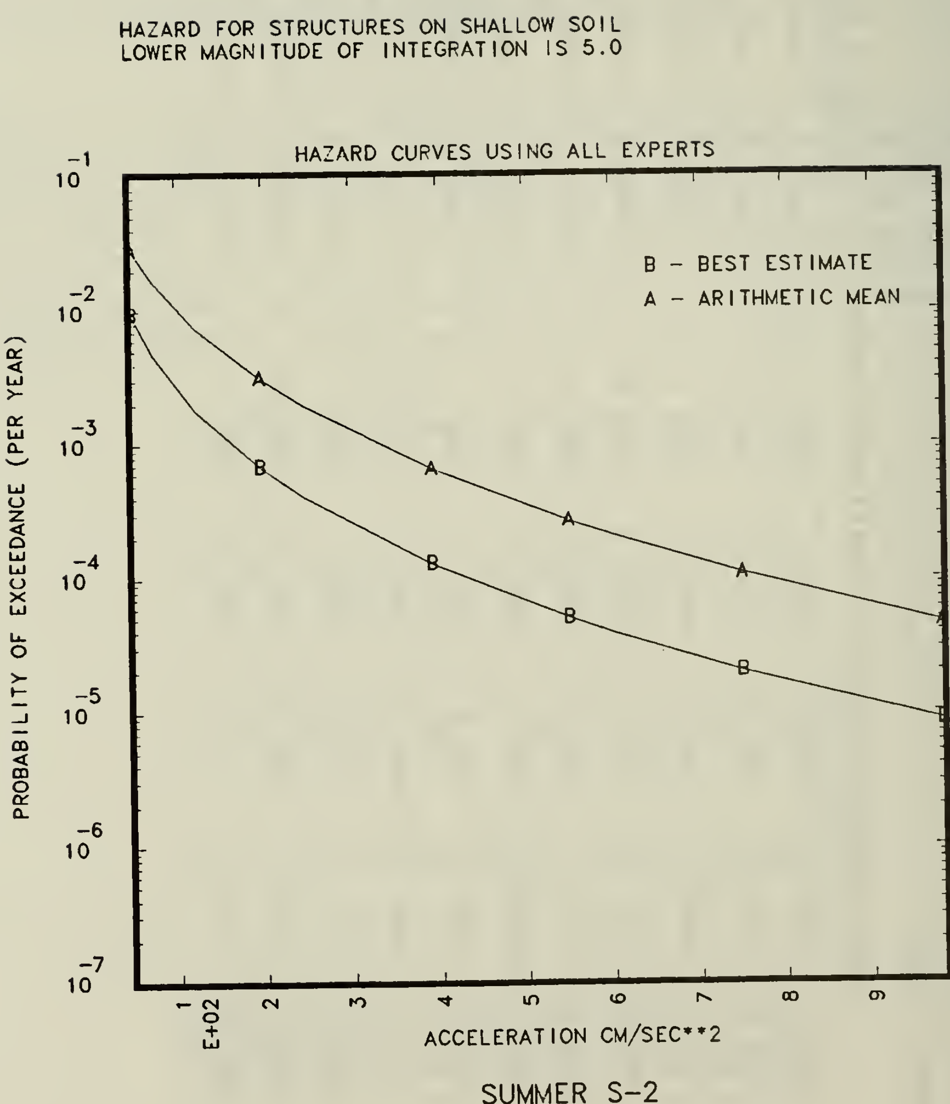


Figure 2.9.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Summer site.

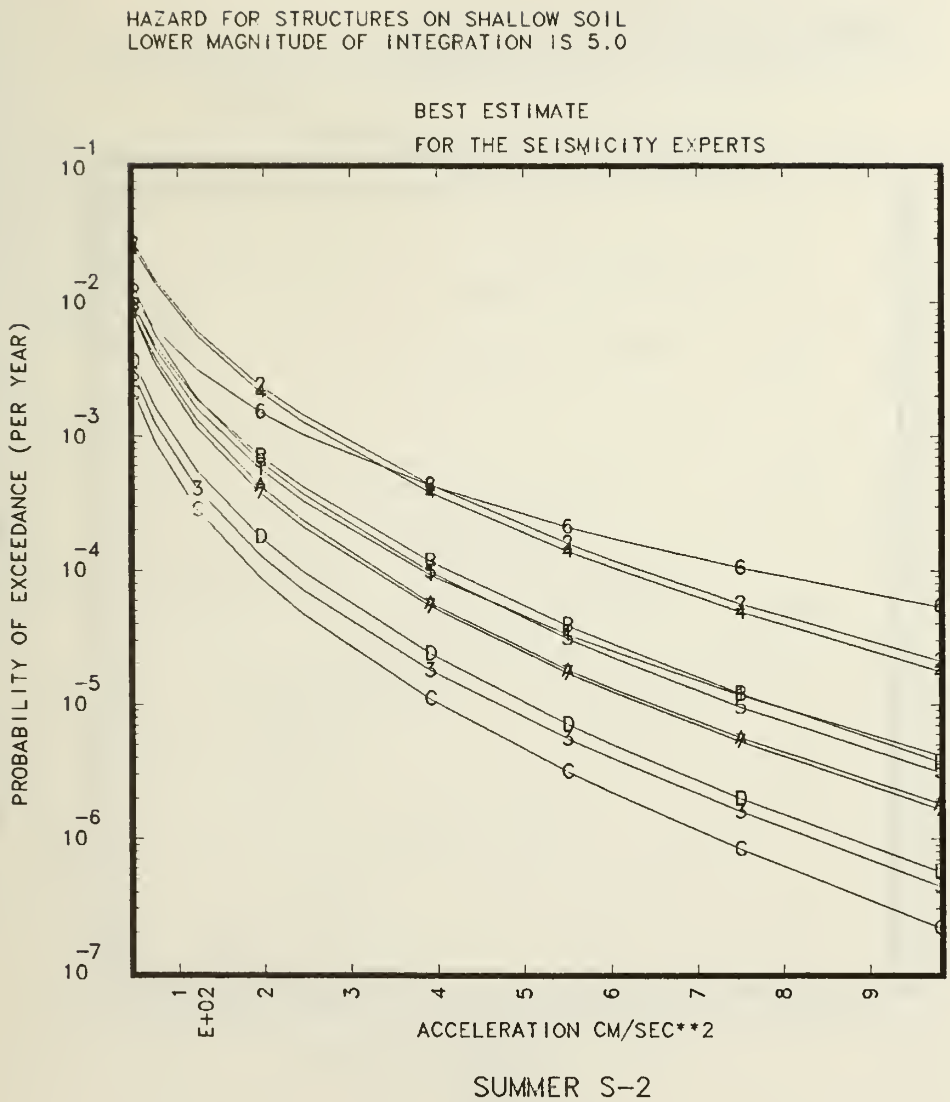
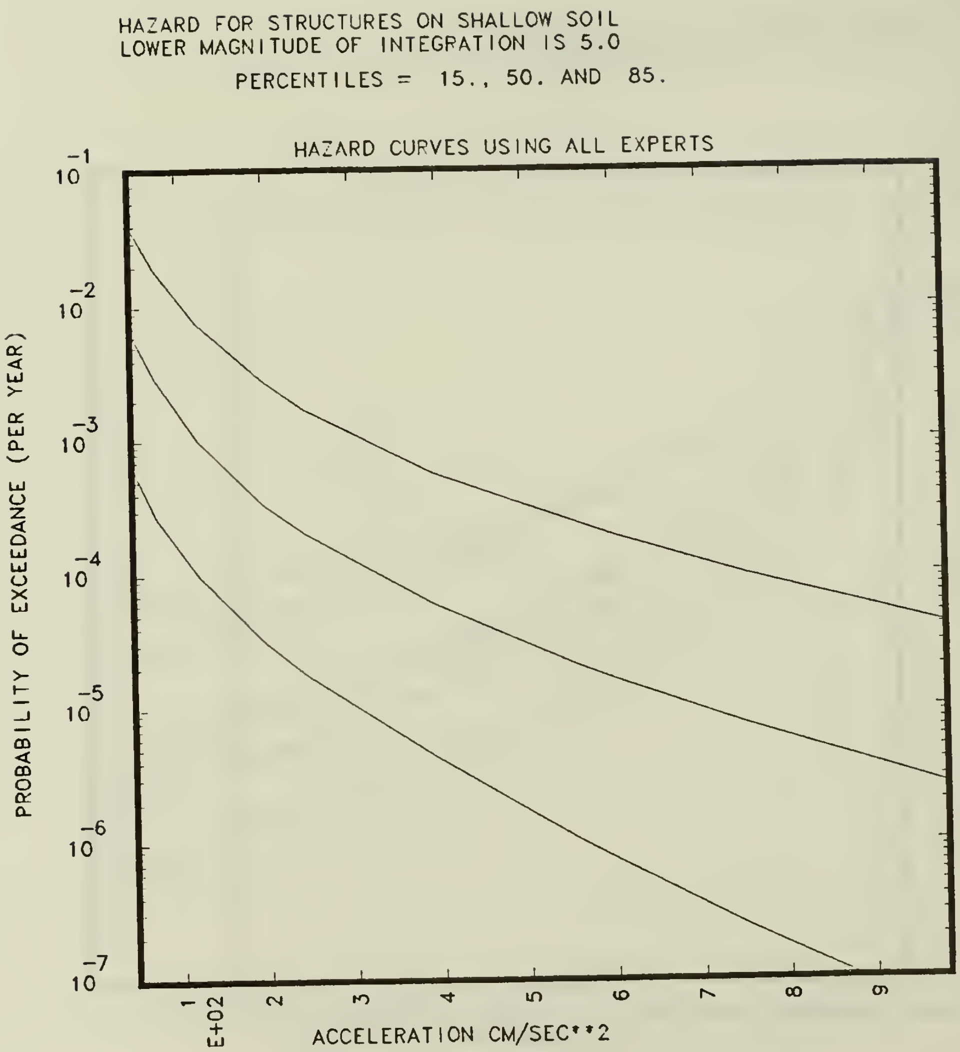


Figure 2.9.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Summer site. Plot symbols given in Table 2.0.



SUMMER S-2

Figure 2.9.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Summer site.

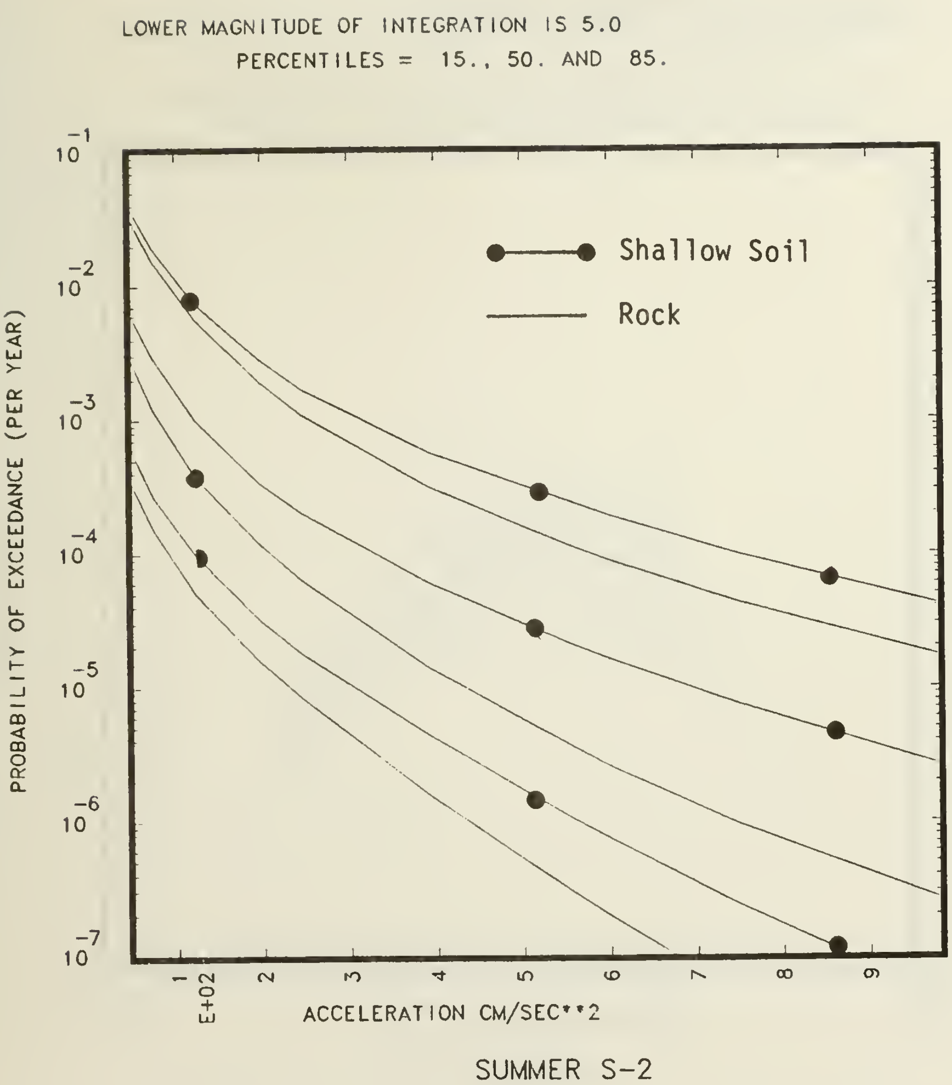


Figure 2.9.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Summer site.

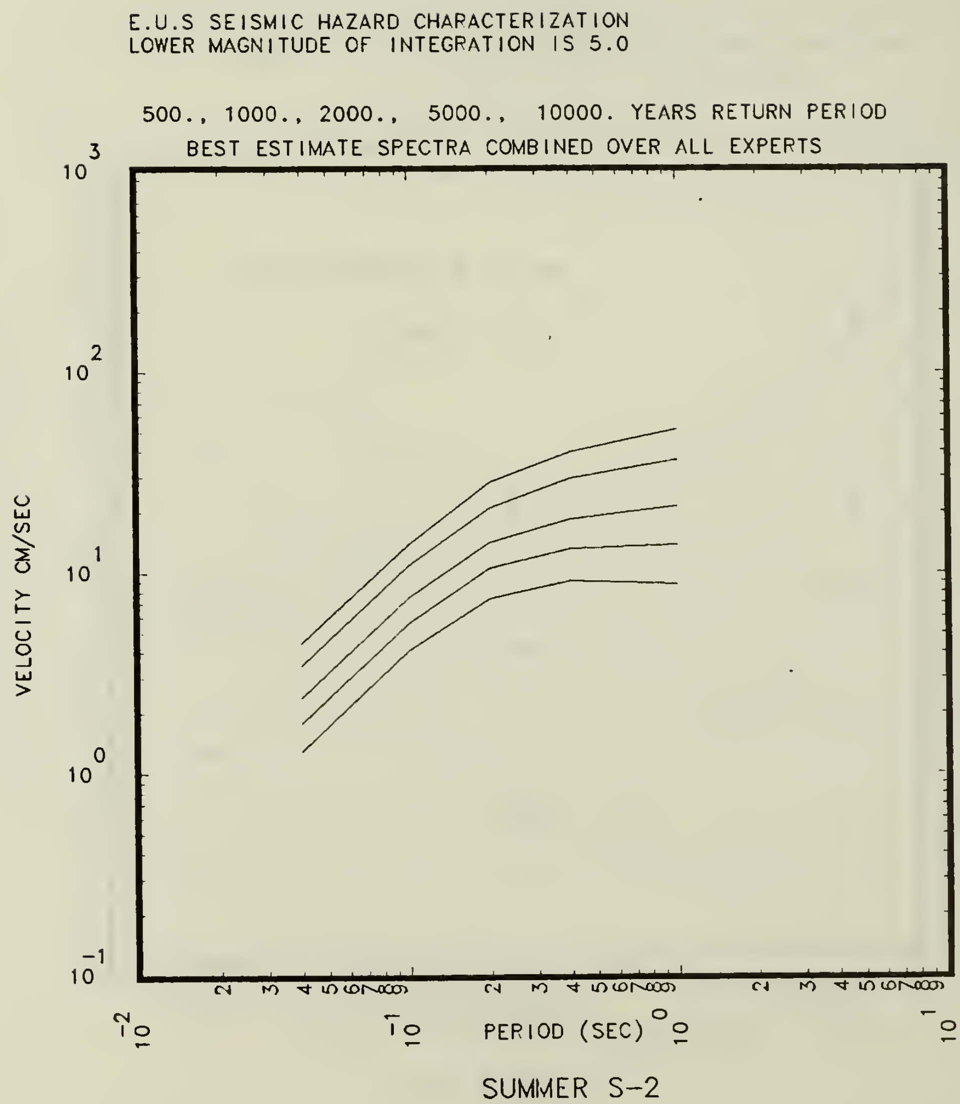


Figure 2.9.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Summer site.

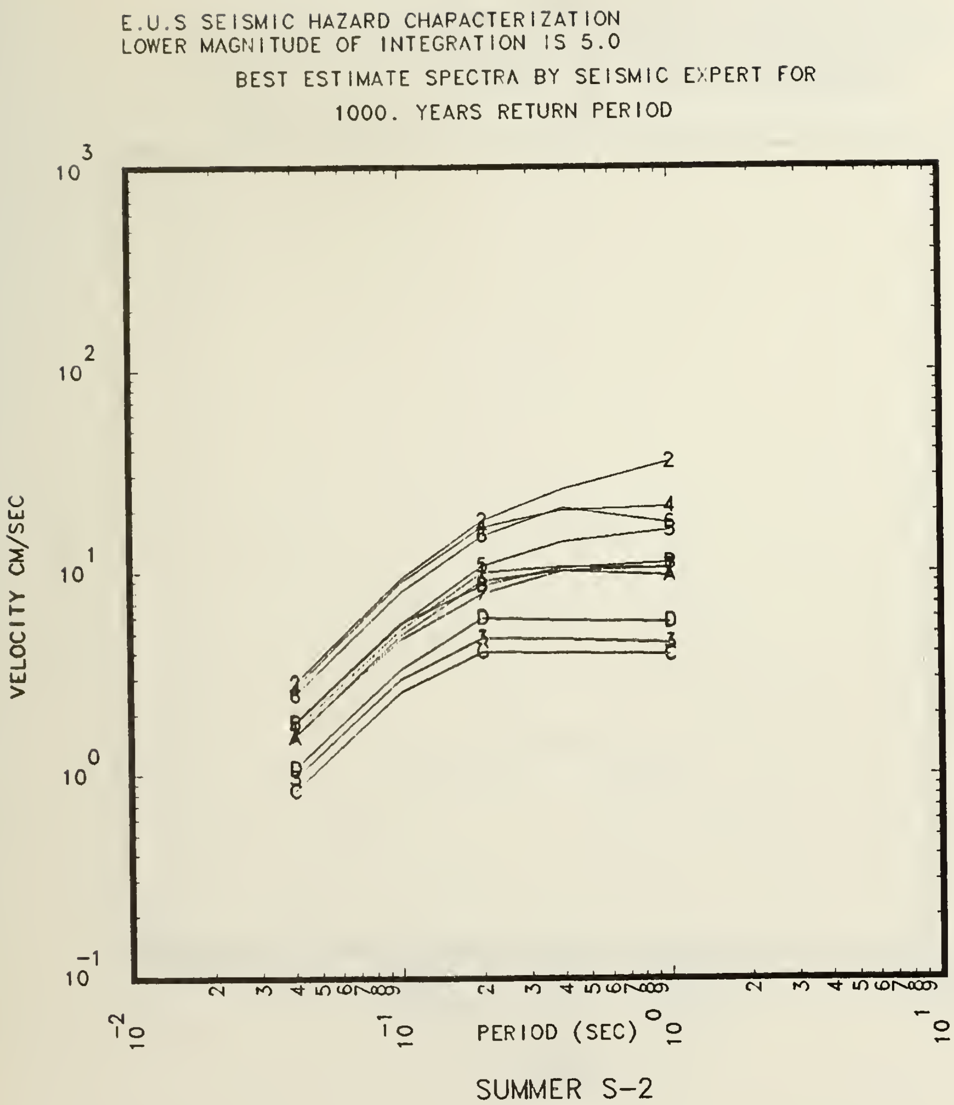


Figure 2.9.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Summer site. Plot symbols are given in Table 2.0

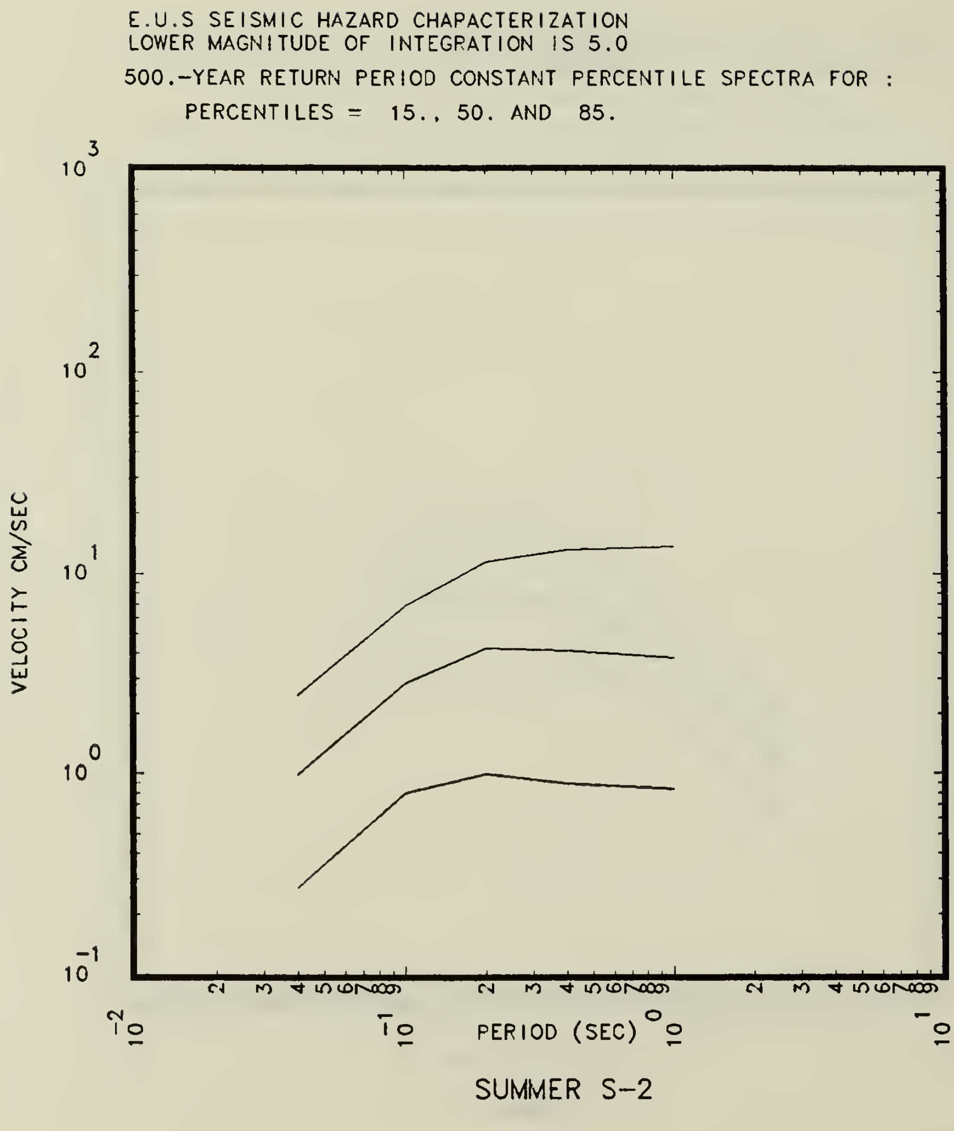


Figure 2.9.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Summer site.

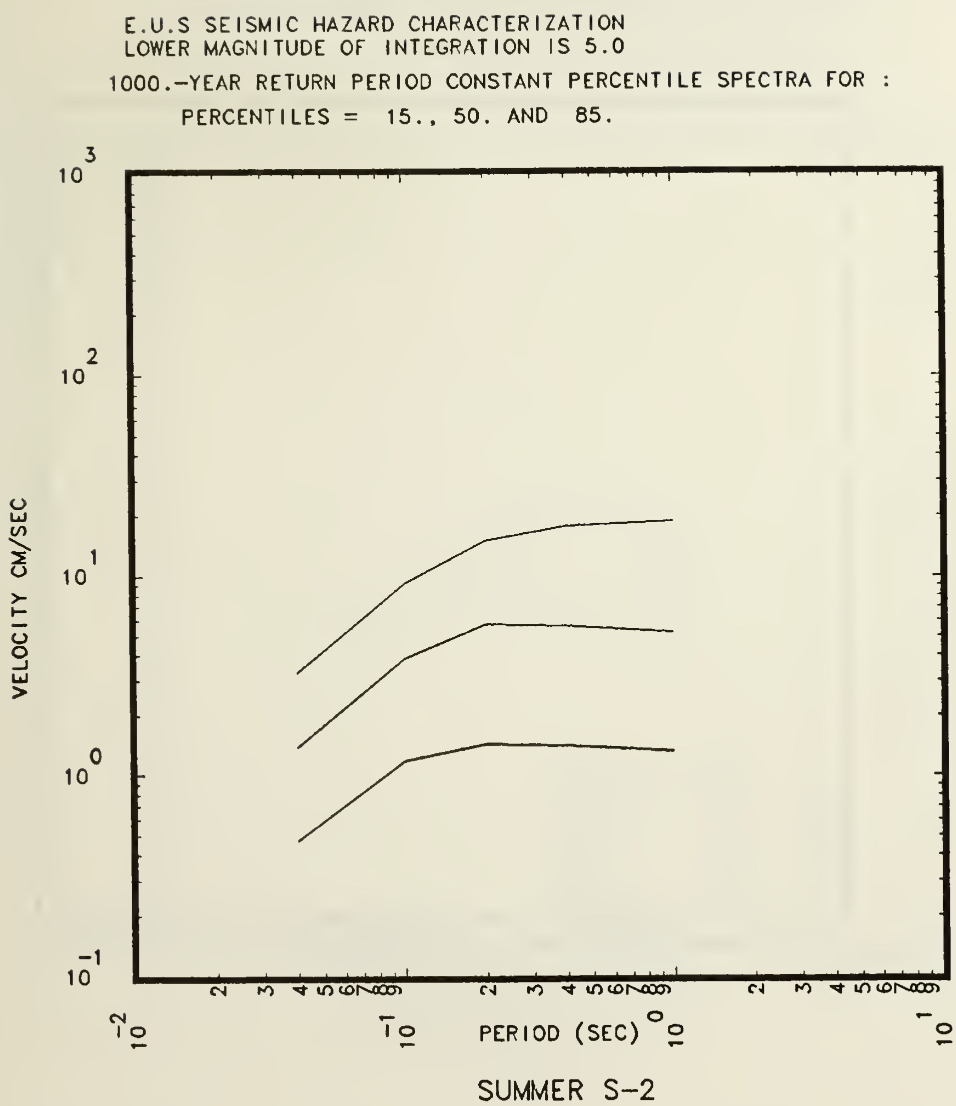


Figure 2.9.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Summer site.

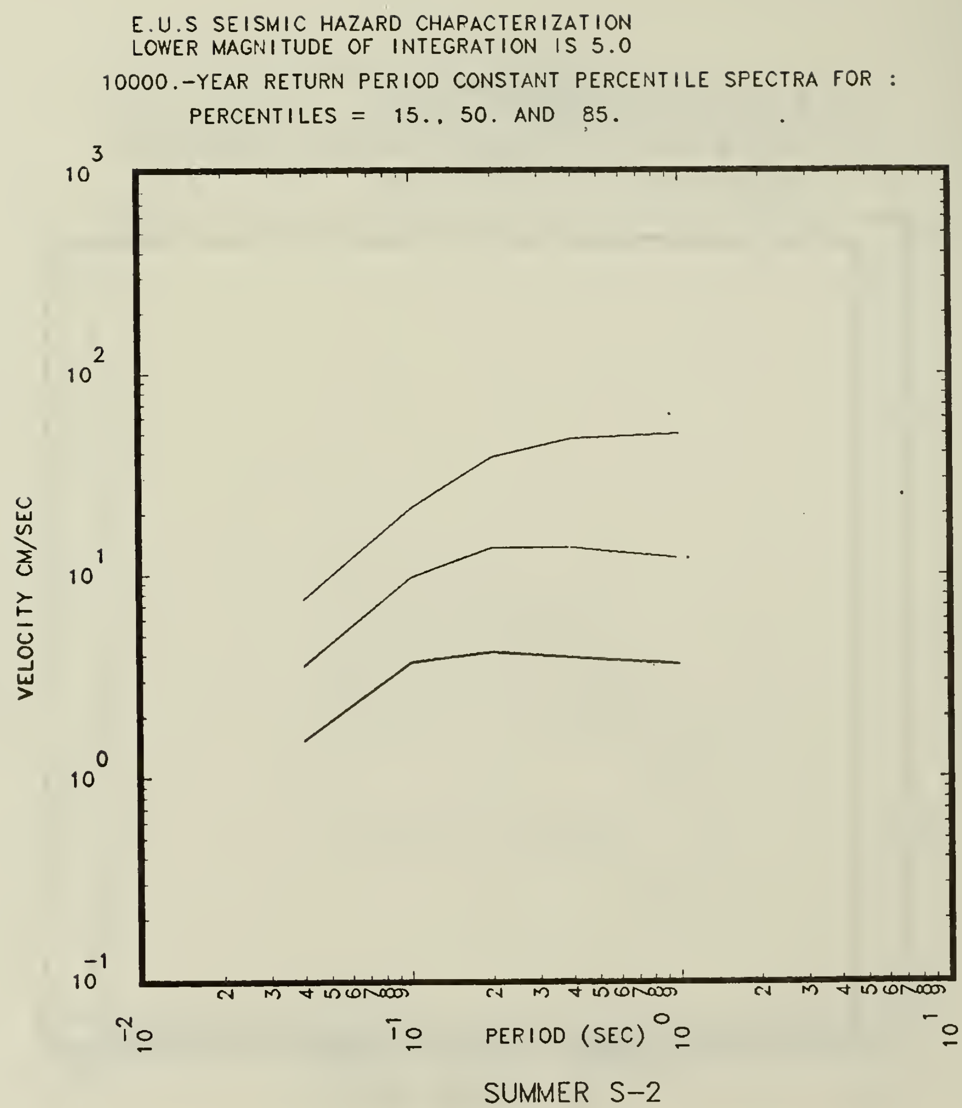


Figure 2.9.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Summer site.

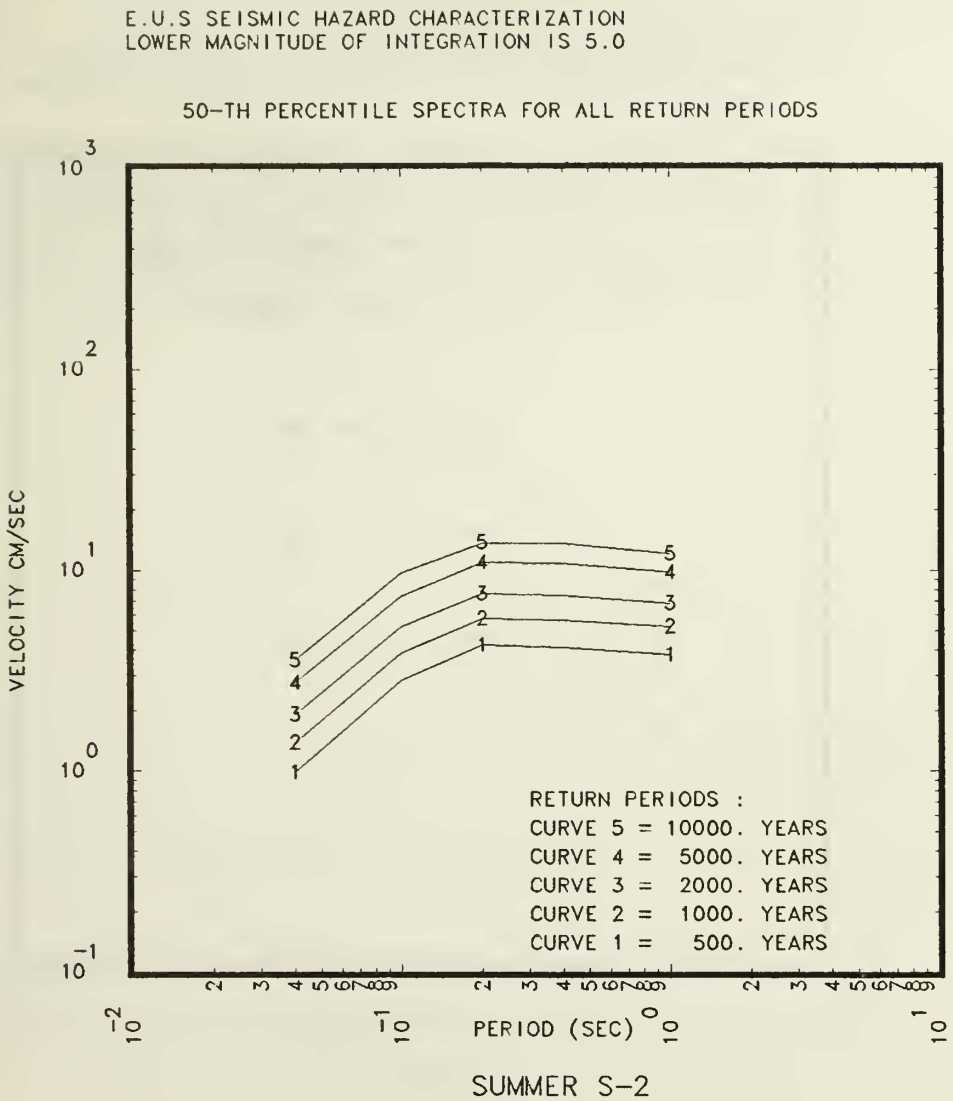


Figure 2.9.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Summer site.

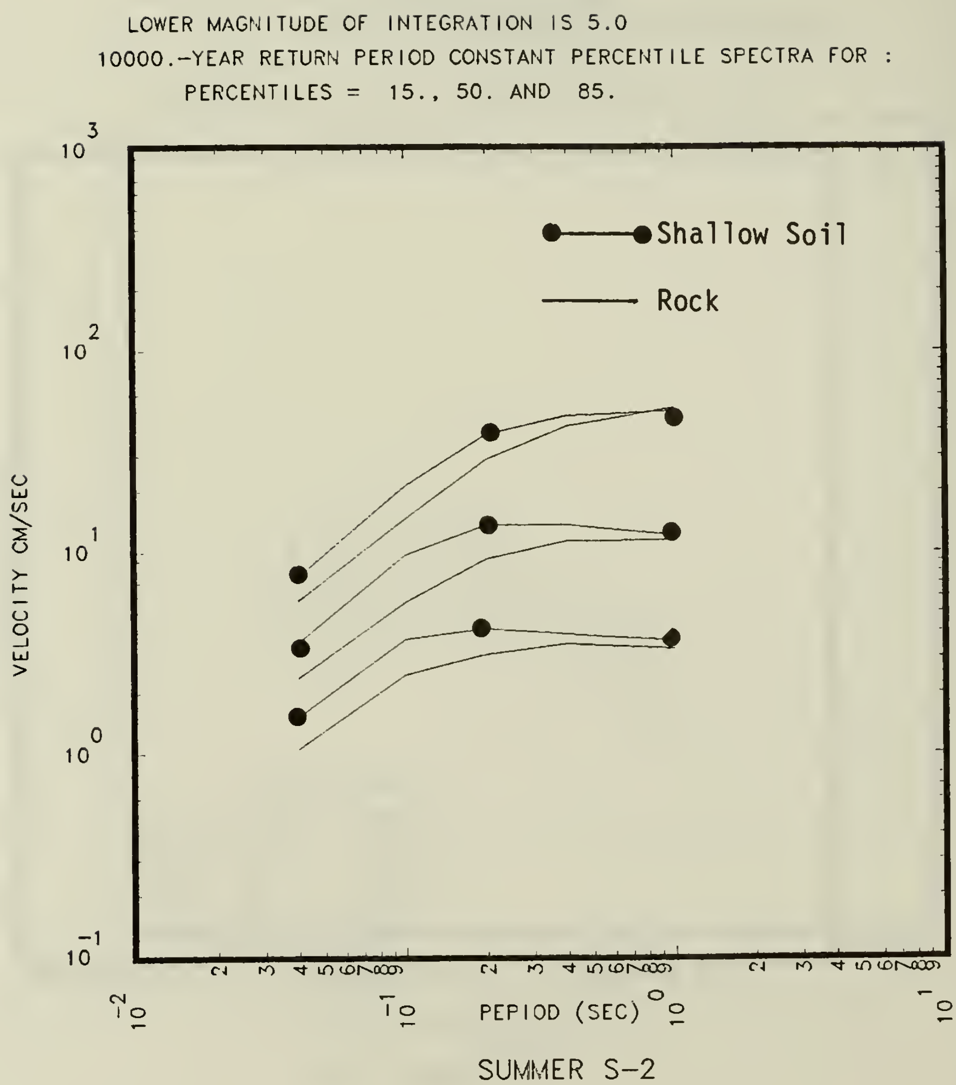


Figure 2.9.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Summer site.

2.10 Arkansas

The location of the Arkansas site is shown in Fig. 1.1 by the plot symbol "A". Most of the structures at the Arkansas site are founded on rock. The hazard results for the rock case are given in Section 2.1 of Vol. V. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Arkansas site was considered to be best represented by our Till-1 soil category described in Section 3.7 of Vol. I. Table 2.10.1 and Figs. 2.10.1 to 2.10.11 give the basic results most applicable to the structures founded on shallow soil at the Arkansas site.

We see by comparing Table 2.10.1 to Table 2.1.1 of Vol. V that the only major change is for S-Expert 1. For the other S-Experts, the percent contributions changes somewhat but no major shift from which zone was the most significant contributor to the BEHC for PGA. We see from Figs. 2.10.4 and 2.10.11 that the differences in CPHCs and CPUHS between the rock and Till-1 cases are about what would be expected based on the sensitivity results given in Section 2.2 of Vol. VI.

TABLE 2.10.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR ARKANSAS S-2

SITE SOIL CATEGORY TILL-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 5	ZONE ID:	ZONE 5	ZONE 9	ZONE 10	ZONE 13	ZONE 5	ZONE 9	ZONE 10	ZONE 15
		% CONT.:	51.	32.	14.	1.	64.	32.	4.	0.
2	COMP. ZO	ZONE ID:	ZONE 18	COMP. ZON	ZONE 4	ZONE 19	ZONE 18	COMP. ZON	ZONE 4	ZONE 19
		% CONT.:	93.	5.	1.	1.	96.	4.	0.	0.
3	ZONE 14	ZONE ID:	ZONE 14	ZONE 13	ZONE 12	ZONE 16	ZONE 14	ZONE 13	ZONE 12	COMP. ZON
		% CONT.:	76.	14.	9.	1.	95.	4.	1.	0.
4	COMP. ZO	ZONE ID:	ZONE 4	ZONE 3	ZONE 2	ZONE 13	ZONE 4	ZONE 3	ZONE 13	COMP. ZON
		% CONT.:	92.	5.	2.	0.	99.	0.	0.	0.
5	COMP. ZO	ZONE ID:	ZONE 15	ZONE 17	ZONE 14	COMP. ZON	ZONE 15	COMP. ZON	ZONE 14	ZONE 8
		% CONT.:	93.	3.	3.	1.	99.	1.	0.	0.
6	ZONE 19	ZONE ID:	ZONE 19	ZONE 25	ZONE 17	ZONE 18	ZONE 19	ZONE 25	ZONE 17	ZONE 18
		% CONT.:	35.	30.	23.	10.	68.	17.	7.	7.
7	ZONE 30	ZONE ID:	ZONE 6	ZONE 30	ZONE 5	ZONE 2 =	ZONE 6	ZONE 30	ZONE 5	ZONE 2 =
		% CONT.:	66.	24.	9.	1.	60.	39.	1.	0.
10	ZONE 19	ZONE ID:	ZONE 29	ZONE 12A	ZONE 19 =	ZONE 13	ZONE 29	ZONE 19 =	ZONE 12A	ZONE 4B
		% CONT.:	54.	24.	21.	2.	76.	21.	3.	0.
11	ZONE 15	ZONE ID:	ZONE 15	ZONE 11	ZONE 10	CZ = ZONE	ZONE 15	ZONE 11	ZONE 10	CZ = ZONE
		% CONT.:	87.	9.	3.	1.	98.	2.	0.	0.
12	ZONE 4 =	ZONE ID:	ZONE 15	ZONE 13	ZONE 14	ZONE 3	ZONE 15	ZONE 14	ZONE 3	ZONE 13
		% CONT.:	34.	27.	22.	7.	80.	9.	6.	4.
13	ZONE 1	ZONE ID:	ZONE 1	ZONE 5	CZ 15	ZONE 4	ZONE 1	ZONE 5	CZ 15	ZONE 3
		% CONT.:	62.	28.	8.	1.	87.	10.	4.	0.

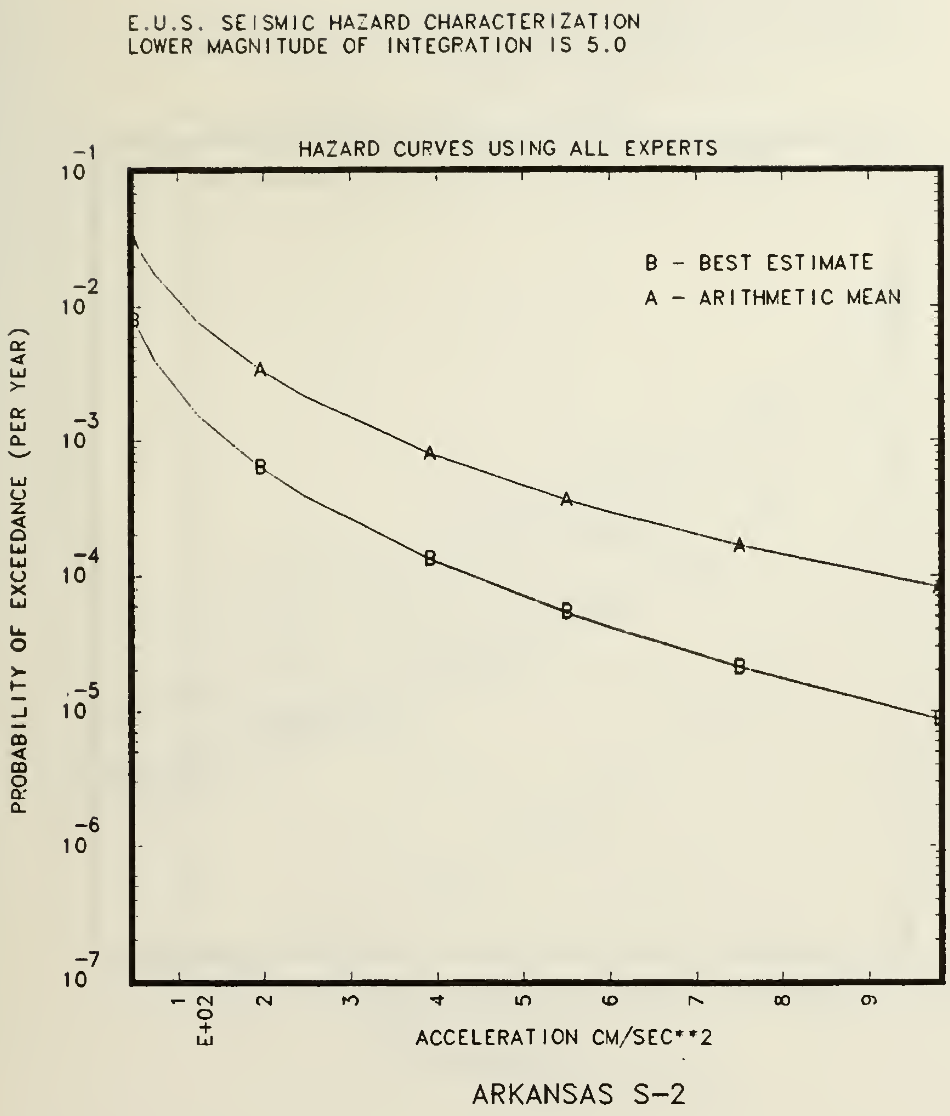


Figure 2.10.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Arkansas site.

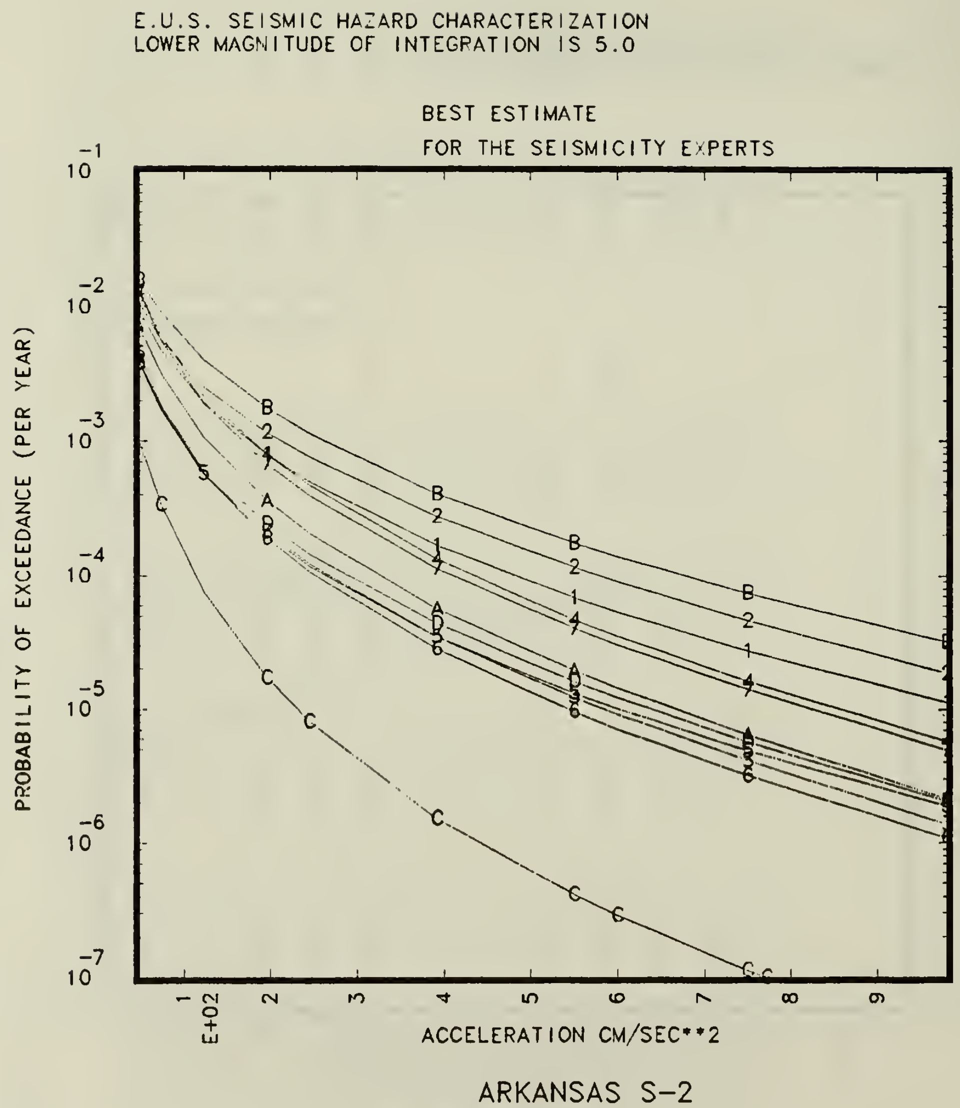


Figure 2.10.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Arkansas site. Plot symbols given in Table 2.0.

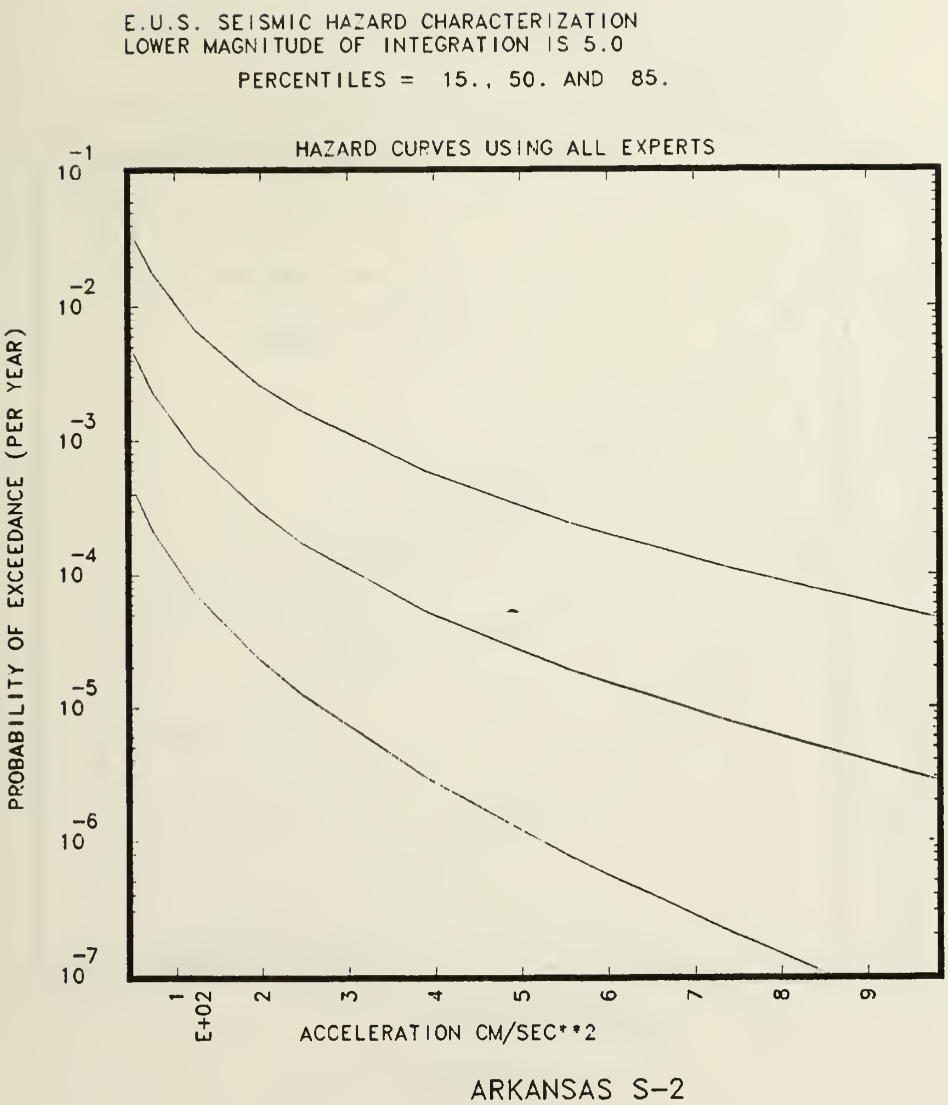


Figure 2.10.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Arkansas site.

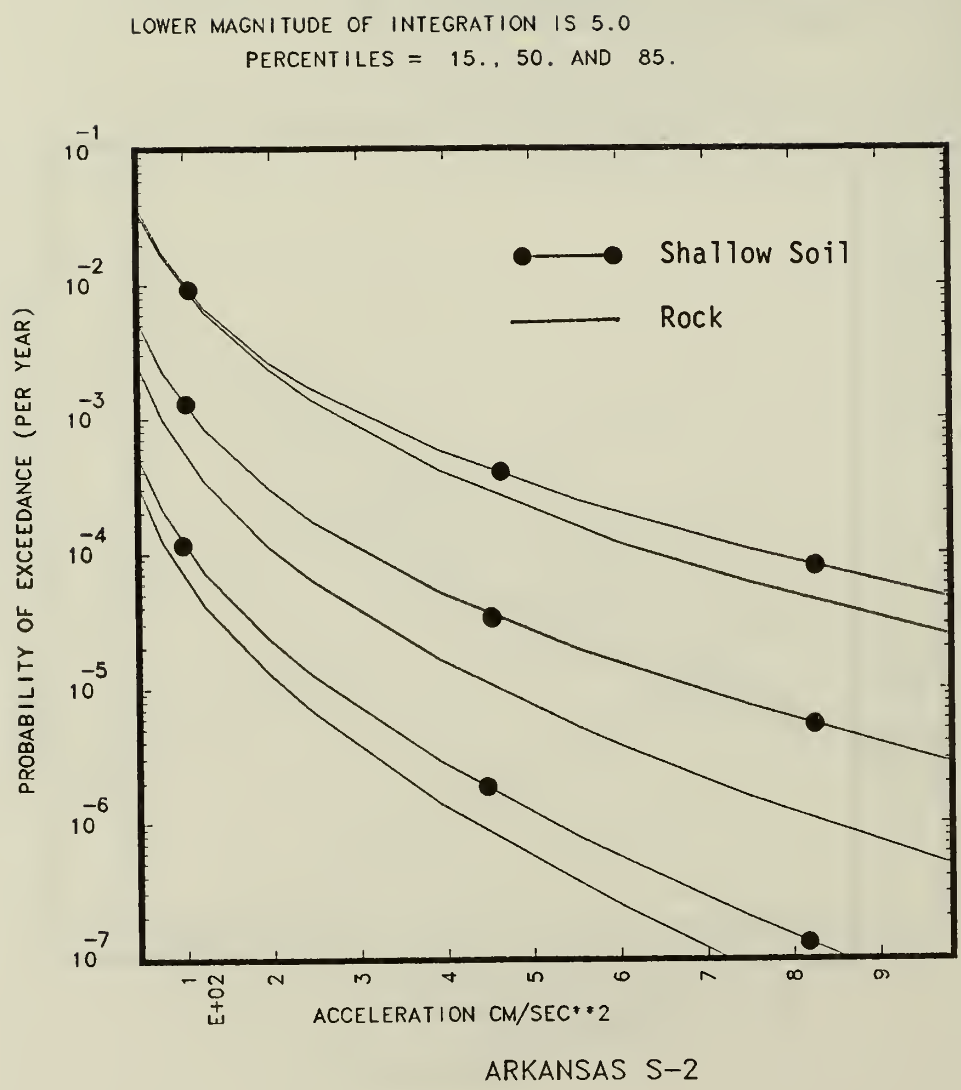


Figure 2.10.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Arkansas site.

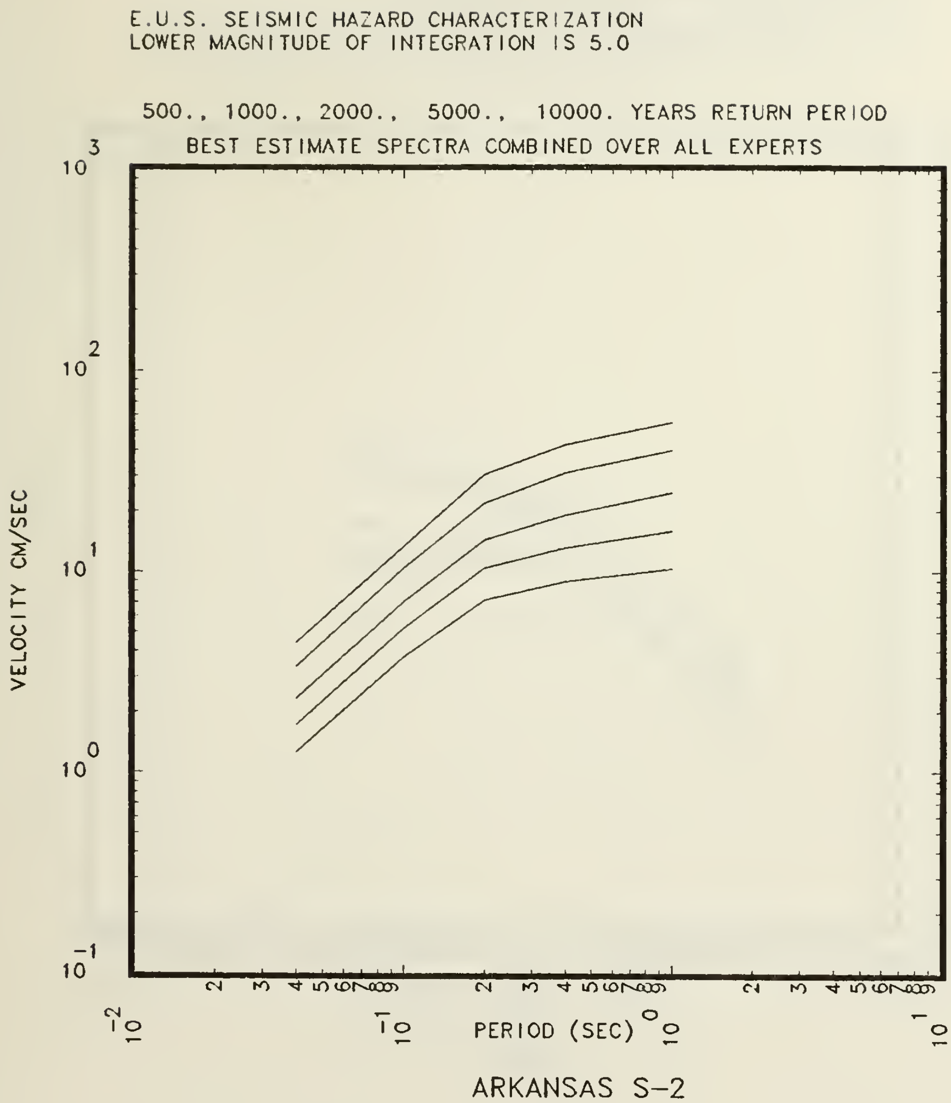


Figure 2.10.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Arkansas site.

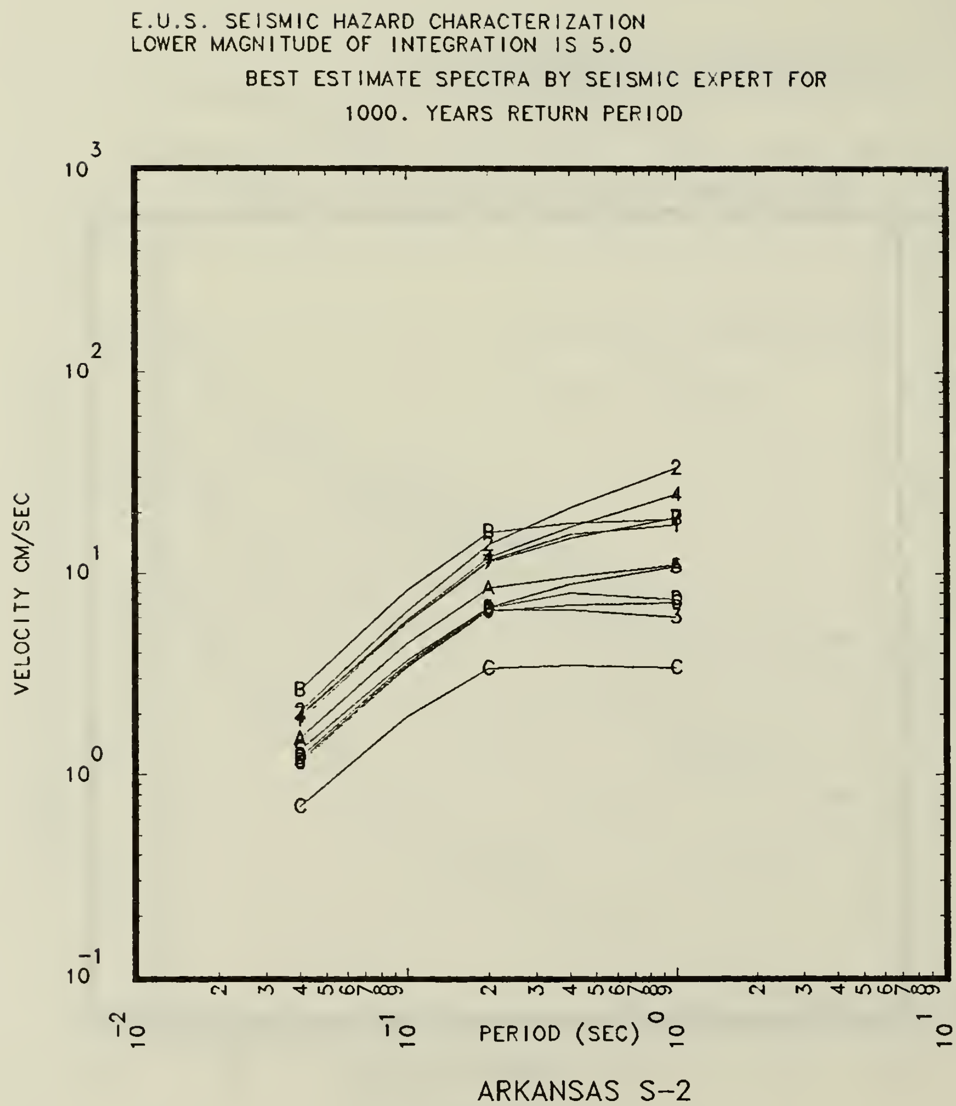


Figure 2.10.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Arkansas site. Plot symbols are given in Table 2.0

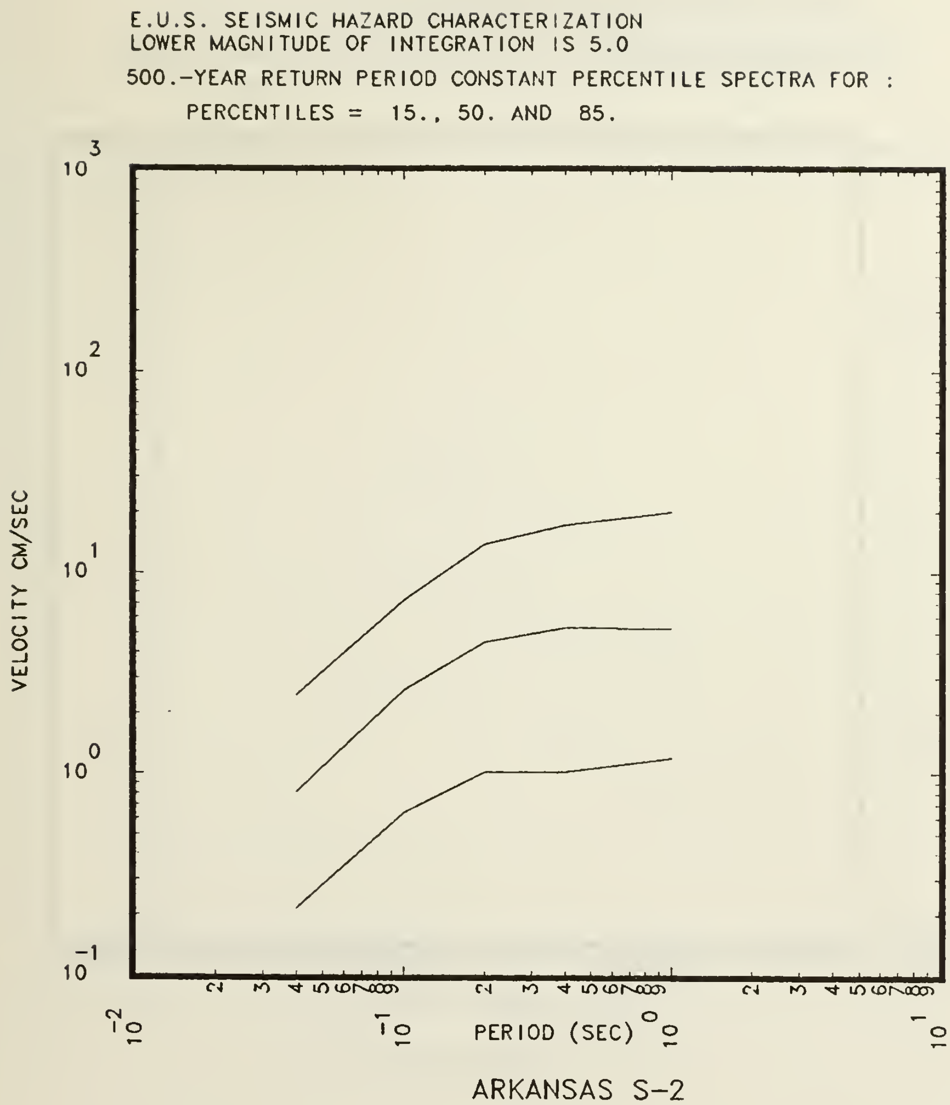


Figure 2.10.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Arkansas site.

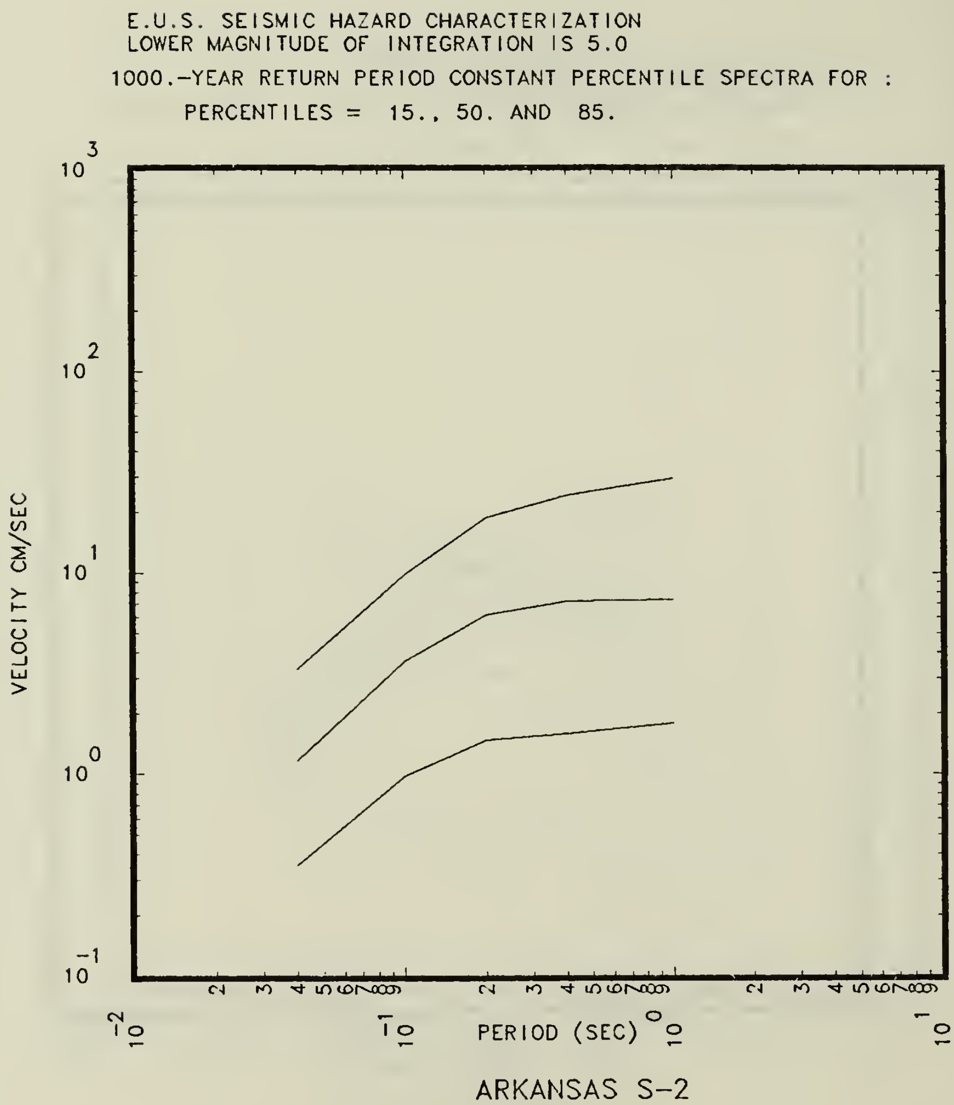


Figure 2.10.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Arkansas site.

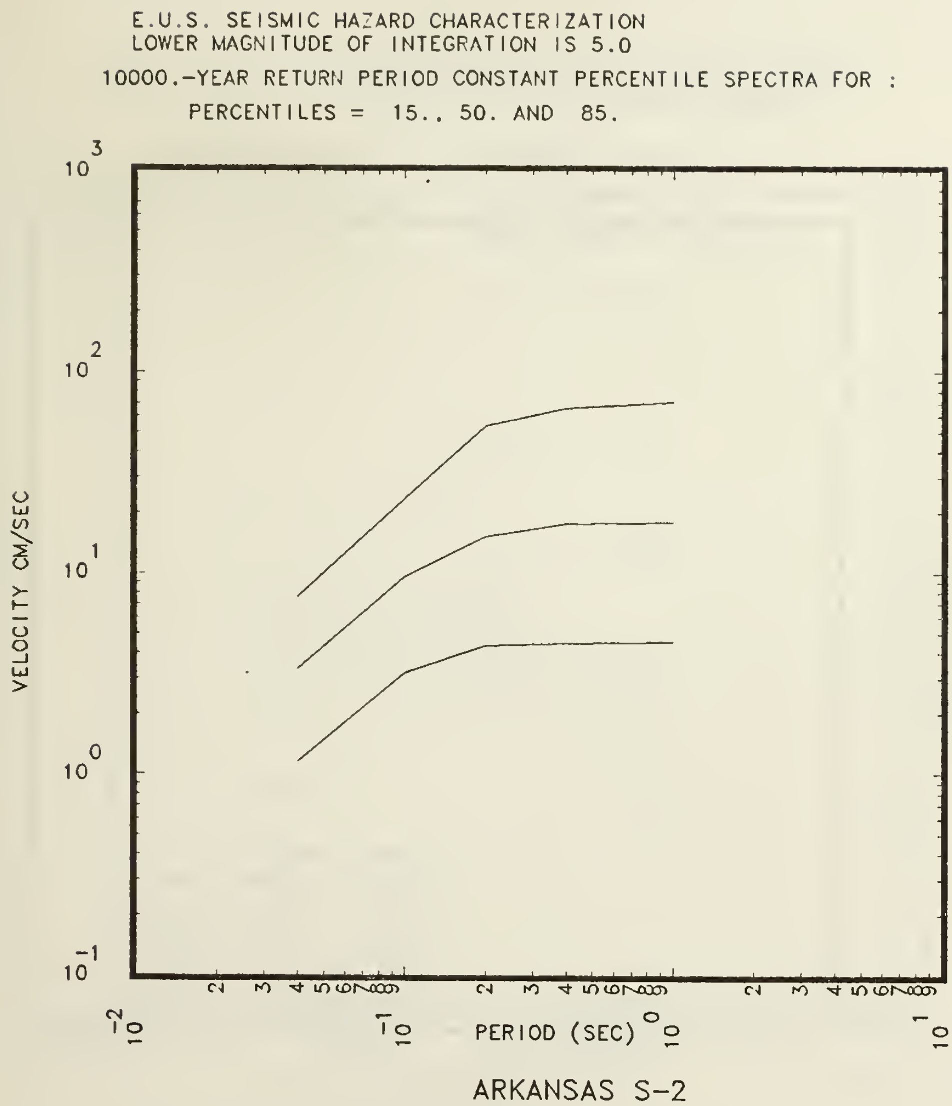


Figure 2.10.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Arkansas site.

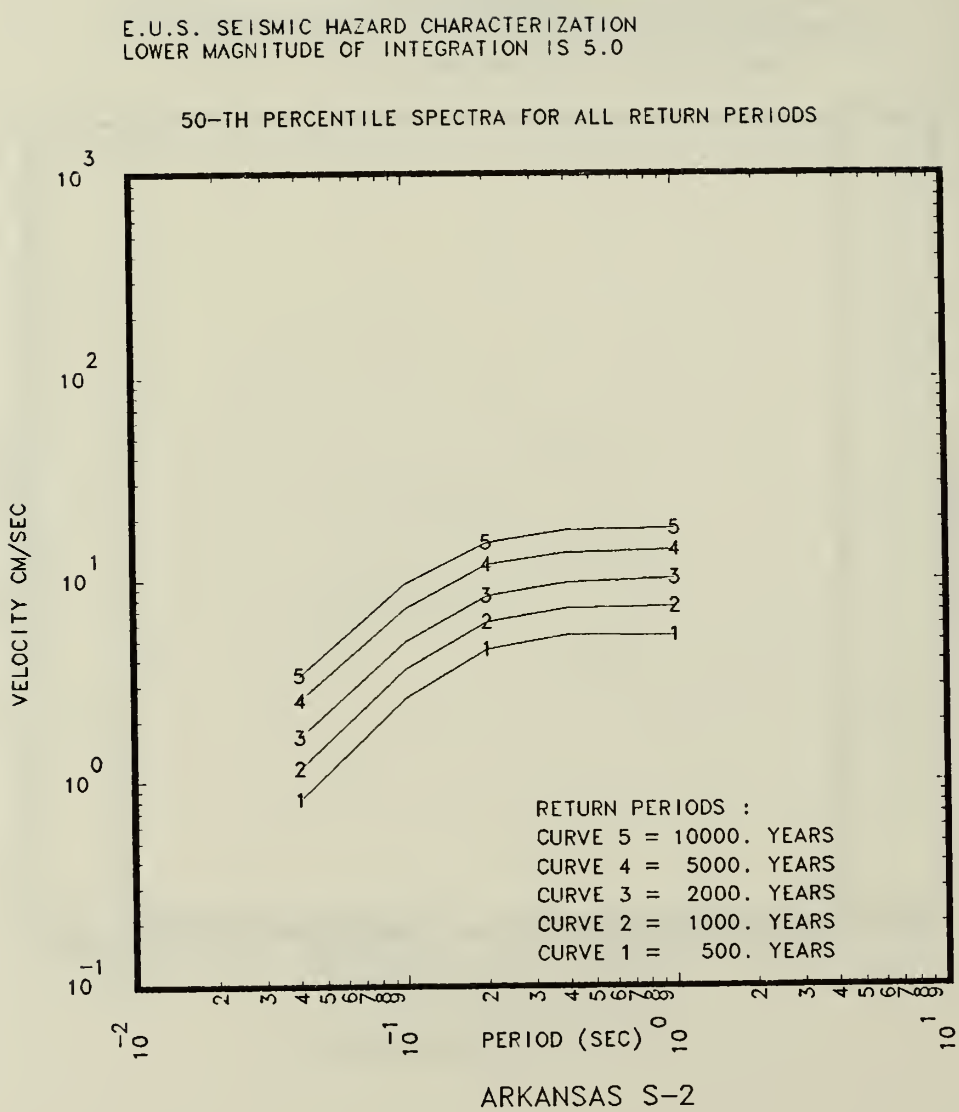


Figure 2.10.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Arkansas site.

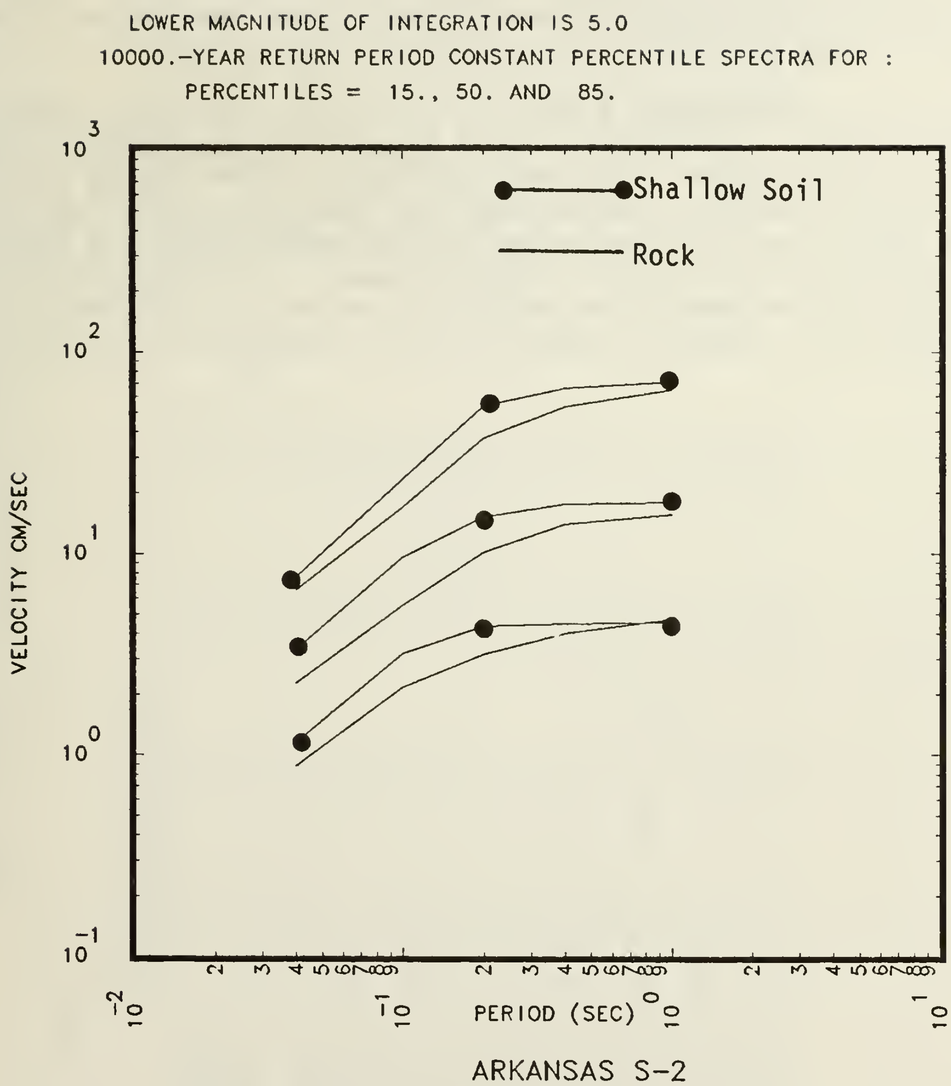


Figure 2.10.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Arkansas site.

2.11 Callaway

The location of the Callaway site is shown in Fig. 1.1 by the plot symbol "B". Most of the structures at the Callaway site are founded on rock. The hazard results for the rock case are given in Section 2.2 of Vol. V. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Callaway site was considered to be best represented by our Sand-1 soil category described in Section 2.2 of Vol. V. Table 2.11.1 and Figs. 2.11.1 to 2.11.11 give the basic results most applicable to the structures founded on shallow soil at the Callaway site.

If Table 2.11.1 is compared to Table 2.2.1 of Vol. V we see a number of significant changes, particularly for S-Experts 3,5,10,11 and 13. For these S-Experts the host becomes much more important for the shallow soil case as compared to the rock case. We can see from Figs. 2.11.4 and 2.11.11 that there are significant differences between the median CPHCs and CPUHS for the shallow soil case as compared to the rock case. The differences are larger than for most of the other sites except Browns Ferry. This variation in the correction for soil category between sites is discussed in Section 3.

TABLE 2.11.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR CALLAWAY S-2

SITE SOIL CATEGORY SAND-1

ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION

S-XPT NUM.	HOST ZONE		AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 15	ZONE ID:	ZONE 10	ZONE 9	ZONE 11	ZONE 15	ZONE 10	ZONE 9	ZONE 11	ZONE 15
		% CONT.:	52.	29.	16.	2.	49.	44.	5.	2.
2	COMP. ZO	ZONE ID:	ZONE 18	ZONE 19	ZONE 20	COMP. ZON	ZONE 18	COMP. ZON	ZONE 19	ZONE 20
		% CONT.:	75.	15.	5.	4.	92.	5.	3.	0.
3	ZONE 16	ZONE ID:	ZONE 12	ZONE 16	ZONE 13	ZONE 14	ZONE 16	ZONE 12	ZONE 13	COMP. ZON
		% CONT.:	64.	22.	13.	0.	47.	46.	6.	1.
4	ZONE 13	ZONE ID:	ZONE 4	ZONE 3	ZONE 5	ZONE 13	ZONE 4	ZONE 3	ZONE 5	ZONE 13
		% CONT.:	69.	20.	11.	1.	90.	7.	2.	1.
5	ZONE 14	ZONE ID:	ZONE 14	ZONE 15	COMP. ZON	ZONE 17	ZONE 14	ZONE 15	COMP. ZON	ZONE 10
		% CONT.:	67.	33.	0.	0.	79.	20.	0.	0.
6	COMP. ZO	ZONE ID:	ZONE 17	ZONE 18	COMP. ZON	ZONE 27	ZONE 17	COMP. ZON	ZONE 18	ZONE 27
		% CONT.:	88.	7.	3.	1.	84.	9.	6.	0.
7	ZONE 2 =	ZONE ID:	ZONE 6	ZONE 5	ZONE 2 =	ZONE 30	ZONE 6	ZONE 2 =	ZONE 5	ZONE 1
		% CONT.:	87.	11.	3.	0.	96.	3.	1.	0.
10	ZONE 19	ZONE ID:	ZONE 19 =	ZONE 13	ZONE 12A	ZONE 32	ZONE 19 =	ZONE 12A	ZONE 13	ZONE 4B
		% CONT.:	43.	31.	26.	0.	92.	6.	3.	0.
11	CZ = ZON	ZONE ID:	ZONE 10	CZ = ZONE	ZONE 11	ZONE 15	CZ = ZONE	ZONE 10	ZONE 11	ZONE 15
		% CONT.:	64.	25.	10.	1.	59.	37.	5.	0.
12	ZONE 4 =	ZONE ID:	ZONE 13	ZONE 15	ZONE 14	ZONE 3	ZONE 15	ZONE 13	ZONE 14	ZONE 3
		% CONT.:	75.	16.	8.	0.	54.	42.	4.	0.
13	CZ 15	ZONE ID:	ZONE 5	CZ 15	ZONE 6	ZONE 3	CZ 15	ZONE 5	ZONE 6	ZONE 3
		% CONT.:	43.	34.	15.	5.	72.	27.	1.	0.

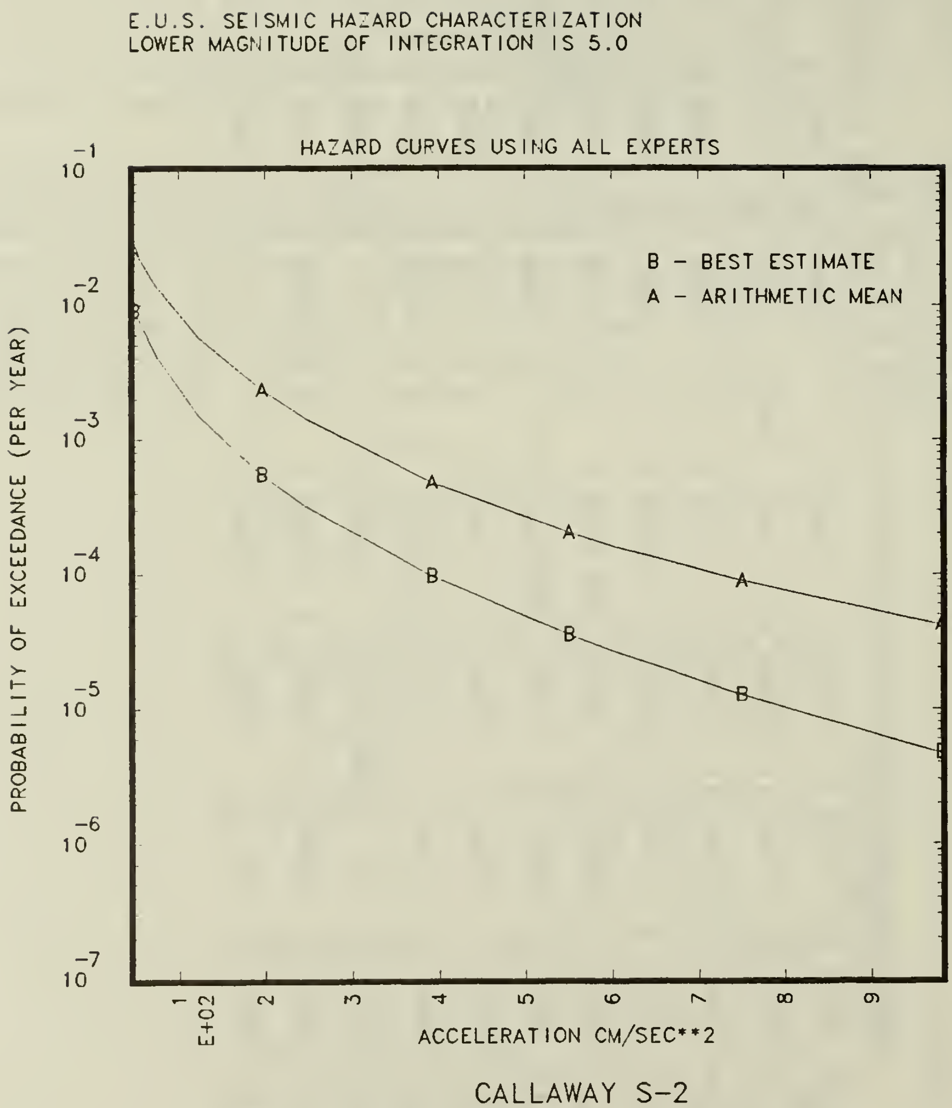


Figure 2.11.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Callaway site.

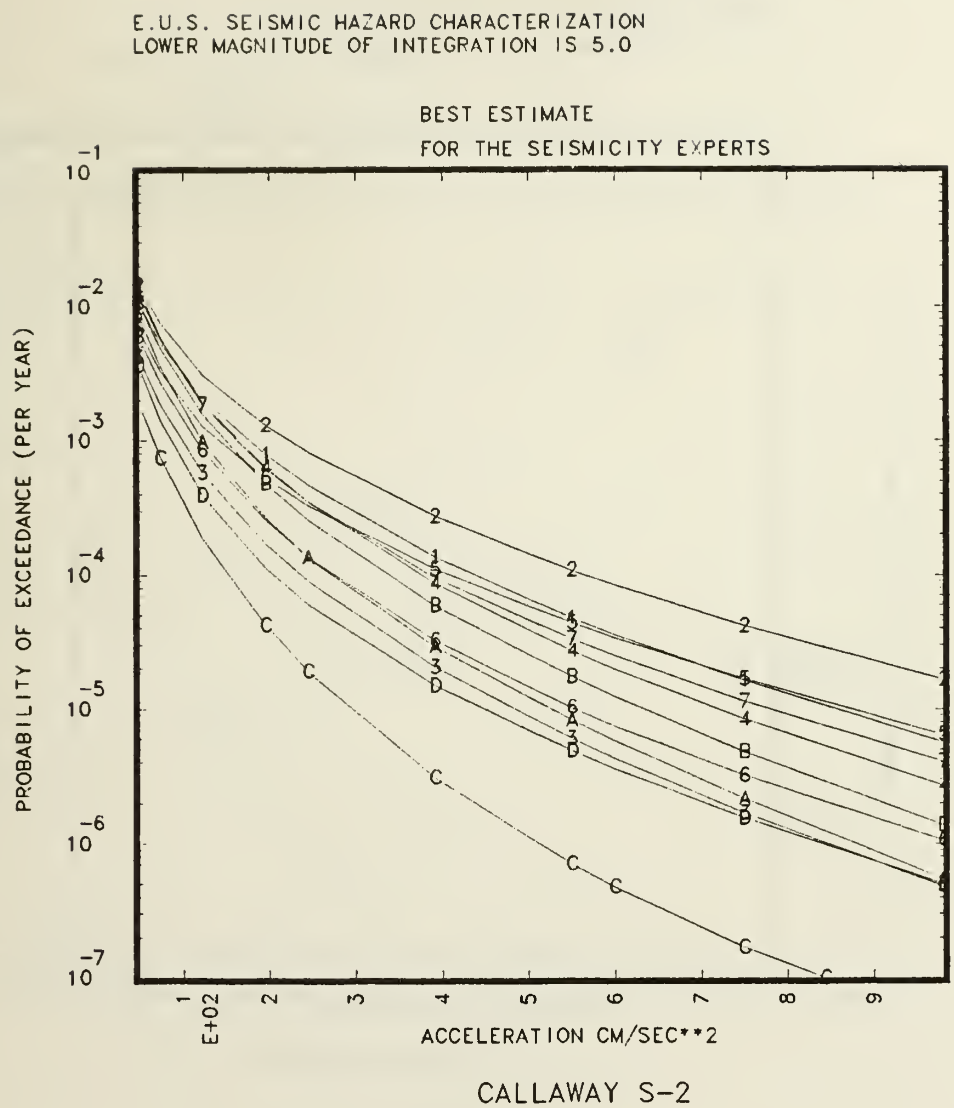


Figure 2.11.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Callaway site. Plot symbols given in Table 2.0.

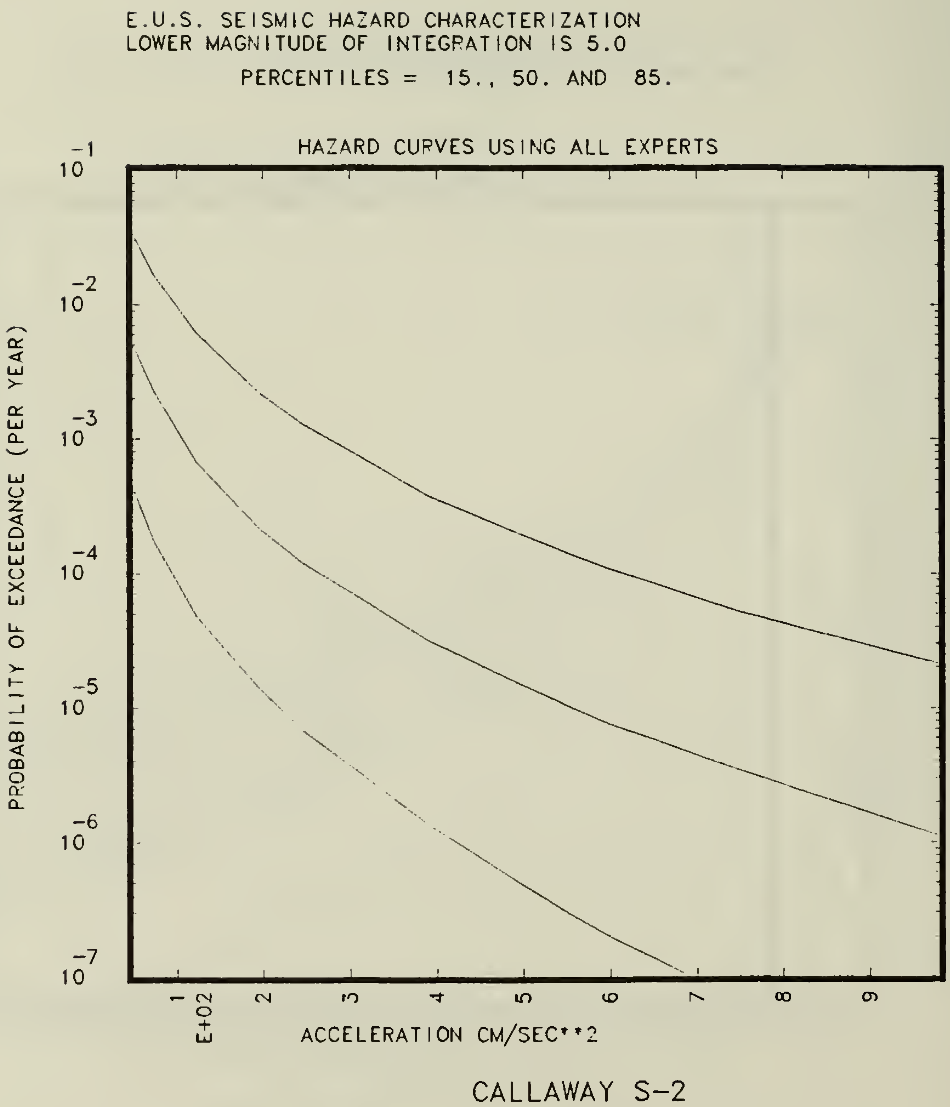
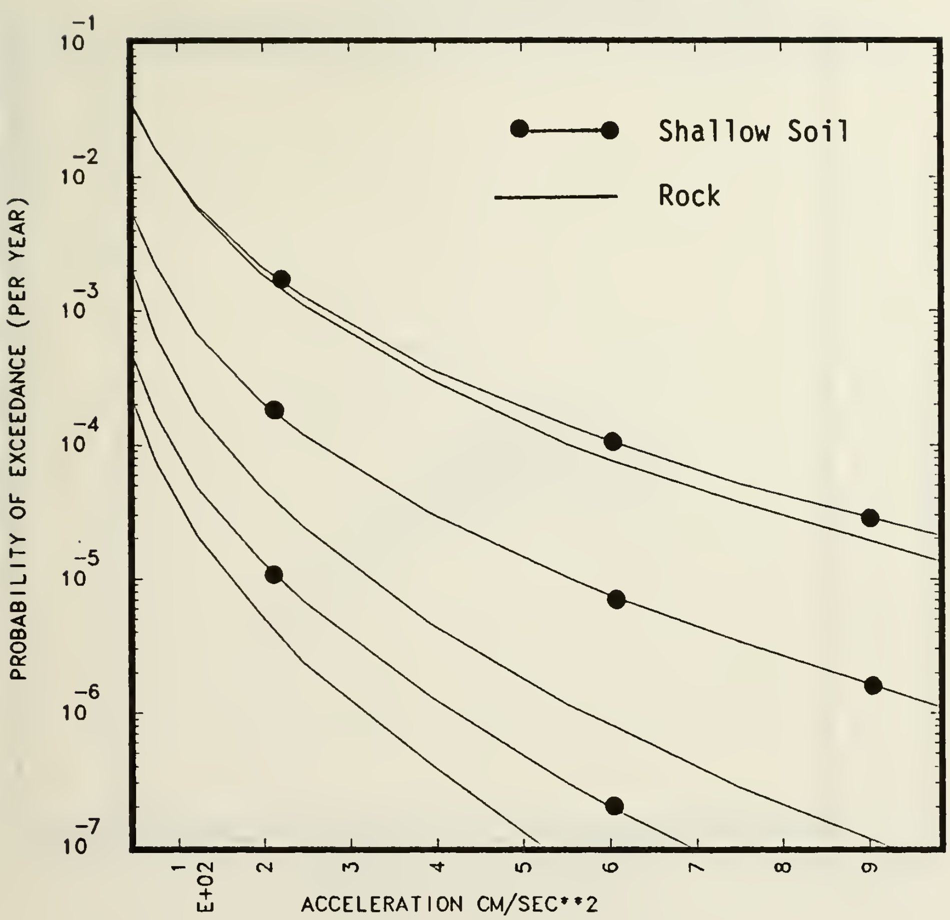


Figure 2.11.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Callaway site.

LOWER MAGNITUDE OF INTEGRATION IS 5.0
PERCENTILES = 15., 50. AND 85.



CALLAWAY S-2

Figure 2.11.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Callaway site.

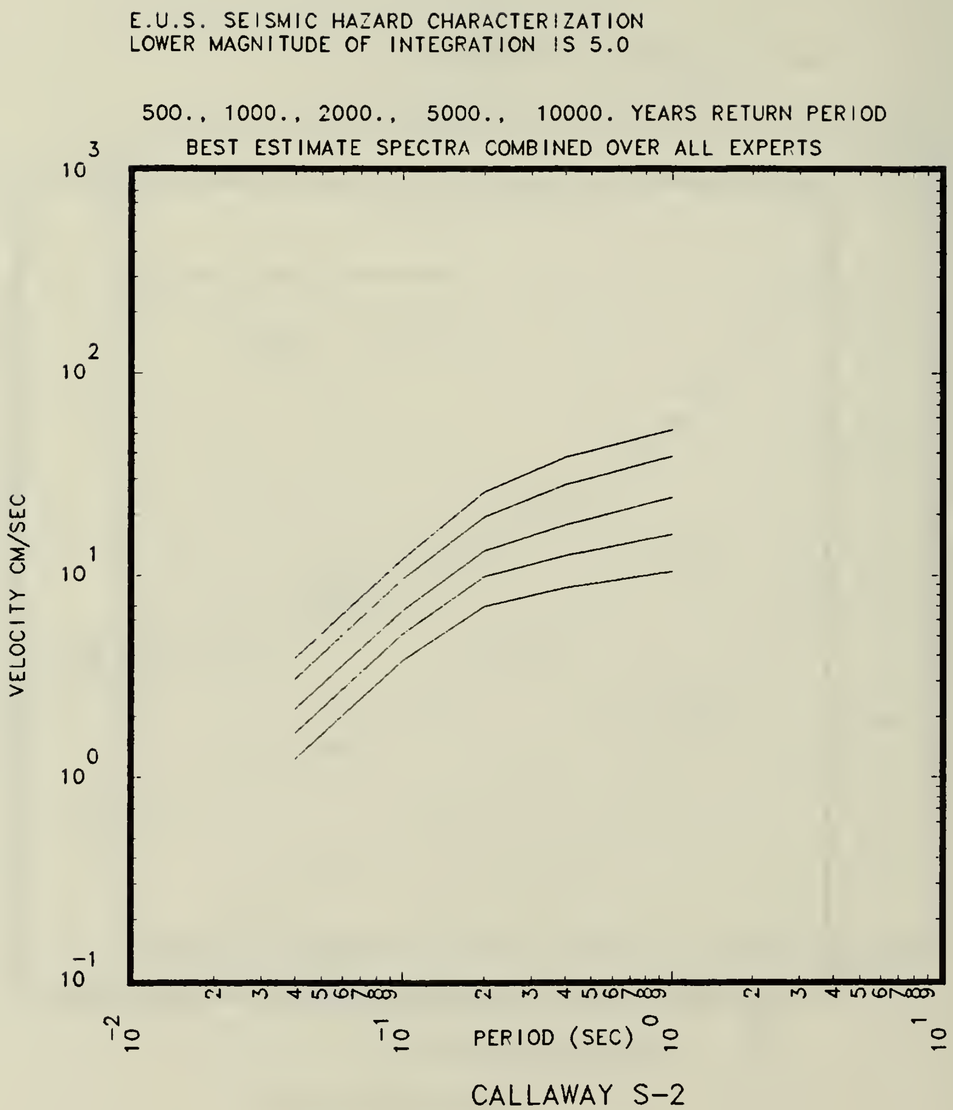


Figure 2.11.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Callaway site.

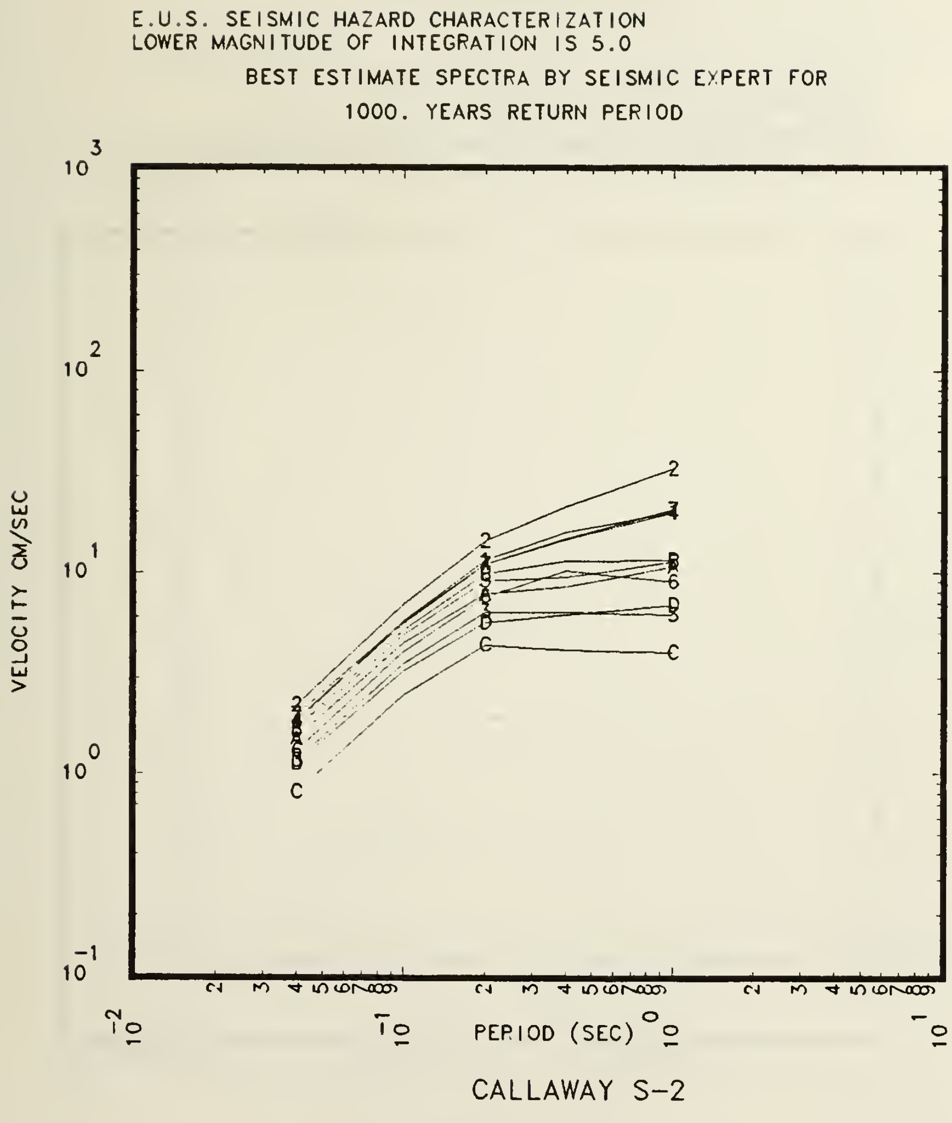


Figure 2.11.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Callaway site. Plot symbols are given in Table 2.0

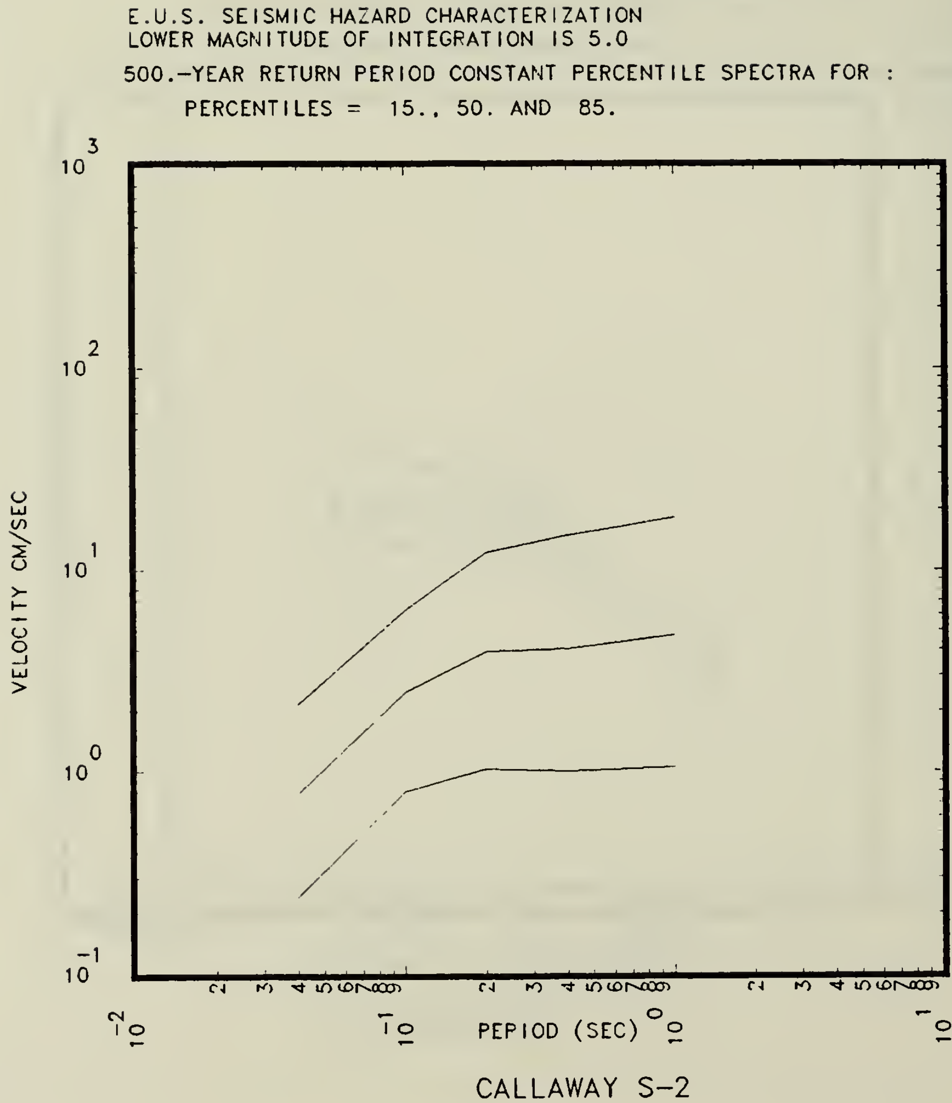


Figure 2.11.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Callaway site.

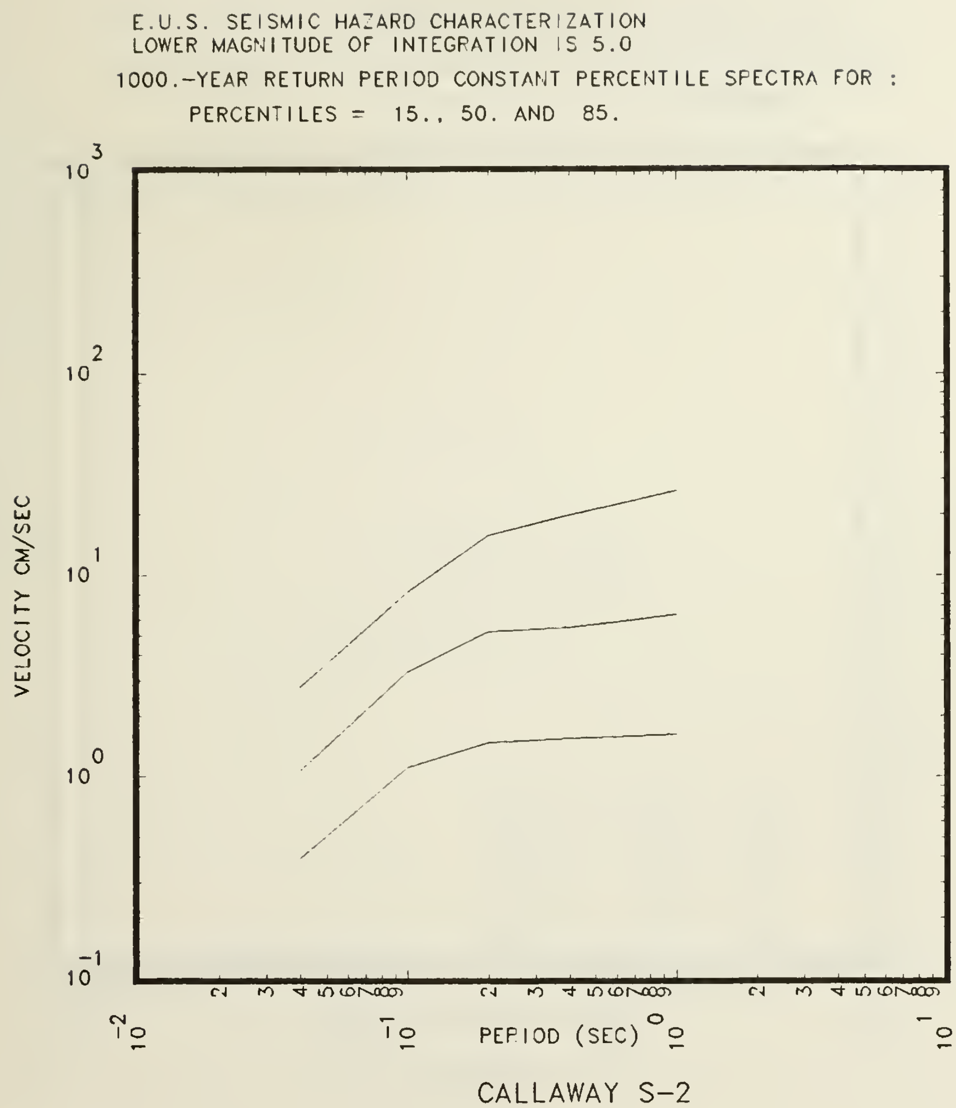


Figure 2.11.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Callaway site.

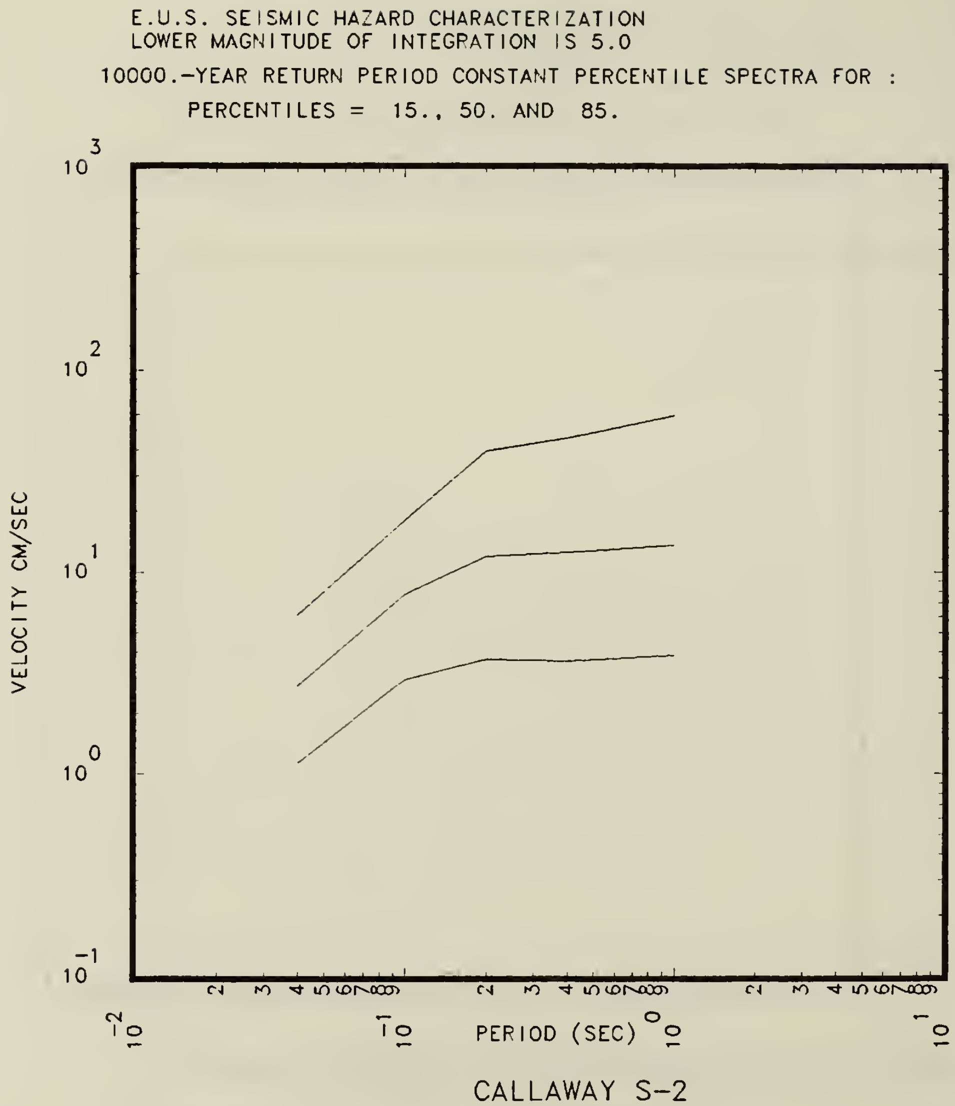


Figure 2.11.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Callaway site.

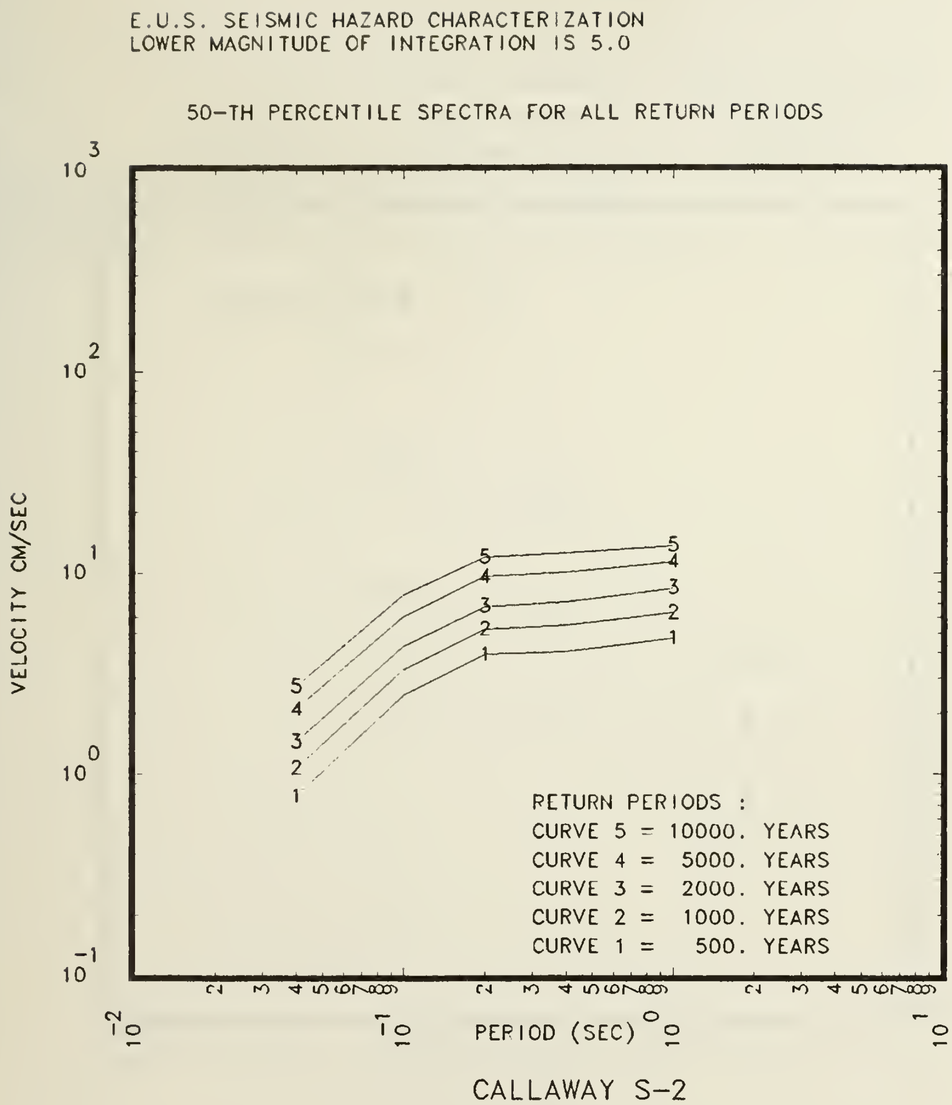


Figure 2.11.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Callaway site.

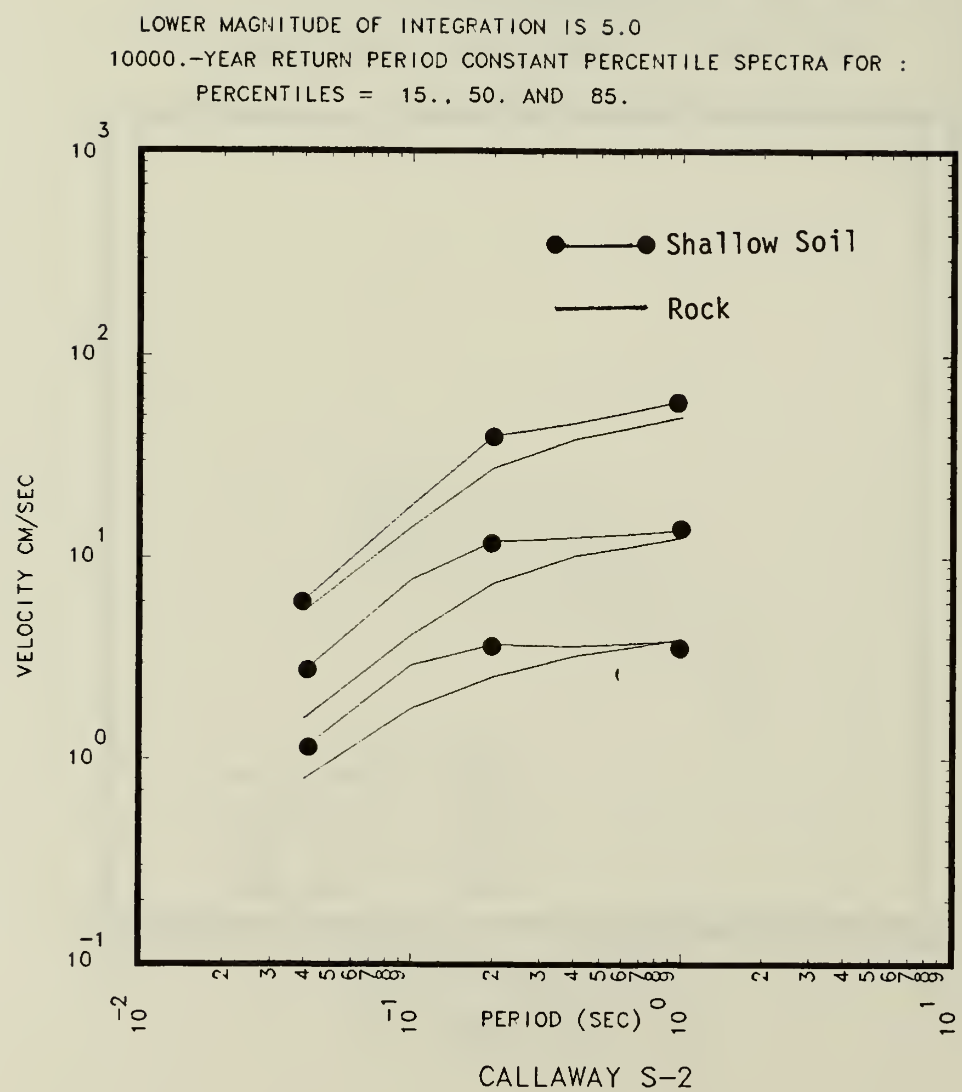


Figure 2.11.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Callaway site.

2.12 Duane Arnold

The location of the Duane Arnold site is shown in Fig. 1.1 by the plot symbol "C". Most of the structures at the Duane Arnold site are founded on rock. The hazard results for the rock case are given in Section 2.6 of Vol. V. In this section we present the hazard curves for the structures founded on shallow soil. The soil at the Duane Arnold site was considered to be best represented by our Till-1 soil category described in Section 3.7 of Vol. I. Table 2.12.1 and Figs. 2.12.1 to 2.12.11 give the basic results most applicable to the structures founded on shallow soil at the Duane Arnold site.

If Table 2.12.1 is compared to Table 2.6.1 of Vol. V we see only relatively minor changes in the percent contribution from the various zones. The differences between the median CPHC and CPUHS for the shallow soil case and the rock case are similar to the differences observed in Section 2.2 of Vol. VI.

TABLE 2.12.1

MOST IMPORTANT ZONES PER S-EXPERT
FOR DUANE ARNOLD S-2

SITE SOIL CATEGORY TILL-1

S-XPT NUM.	HOST ZONE		ZONES CONTRIBUTING MOST SIGNIFICANTLY TO THE PGA BEHC AND % OF CONTRIBUTION AT LOW PGA(0.125G)				AT HIGH PGA(0.60G)			
1	ZONE 15	ZONE ID:	ZONE 9	ZONE 11	ZONE 10	ZONE 15	ZONE 9	ZONE 15	ZONE 11	ZONE 10
		% CONT.:	39.	31.	16.	11.	50.	23.	22.	5.
2	COMP. ZO	ZONE ID:	ZONE 18	COMP. ZON	ZONE 20	ZONE 21	ZONE 18	COMP. ZON	ZONE 21	ZONE 3
		% CONT.:	75.	20.	3.	2.	61.	39.	0.	0.
3	COMP. ZO	ZONE ID:	COMP. ZON	ZONE 13	ZONE 12	ZONE 15	COMP. ZON	ZONE 13	ZONE 12	ZONE 15
		% CONT.:	66.	14.	12.	7.	98.	2.	0.	0.
4	ZONE 13	ZONE ID:	ZONE 4	ZONE 6	ZONE 5	ZONE 13	ZONE 4	ZONE 13	ZONE 6	COMP. ZON
		% CONT.:	67.	22.	4.	4.	81.	15.	4.	0.
5	COMP. ZO	ZONE ID:	ZONE 15	COMP. ZON	ZONE 14	ZONE 12	ZONE 15	COMP. ZON	ZONE 4	ZONE 12
		% CONT.:	85.	11.	3.	1.	82.	18.	0.	0.
6	ZONE 22	ZONE ID:	ZONE 22	ZONE 17	COMP. ZON	ZONE 18	ZONE 22	COMP. ZON	ZONE 17	ZONE 18
		% CONT.:	60.	23.	11.	5.	90.	7.	2.	1.
7	ZONE 3	ZONE ID:	ZONE 6	ZONE 3	ZONE 5	ZONE 2 =	ZONE 6	ZONE 3	ZONE 2 =	ZONE 4
		% CONT.:	85.	12.	2.	1.	68.	32.	1.	0.
10	ZONE 19	ZONE ID:	ZONE 19 =	ZONE 12A	ZONE 32	ZONE 26A	ZONE 19 =	ZONE 10	ZONE 12A	ZONE 13
		% CONT.:	94.	4.	1.	1.	100.	0.	0.	0.
11	CZ = ZON	ZONE ID:	CZ = ZONE	ZONE 10	ZONE 11	ZONE 15	CZ = ZONE	ZONE 10	ZONE 11	ZONE 6
		% CONT.:	83.	13.	4.	0.	99.	1.	0.	0.
12	ZONE 4 =	ZONE ID:	ZONE 15	ZONE 13	ZONE 14	ZONE 7	ZONE 15	ZONE 5	ZONE 6	ZONE 7
		% CONT.:	62.	20.	15.	3.	100.	0.	0.	0.
13	CZ 15	ZONE ID:	CZ 15	ZONE 5	ZONE 6	ZONE 4	CZ 15	ZONE 5	ZONE 1	ZONE 3
		% CONT.:	83.	16.	1.	0.	98.	2.	0.	0.

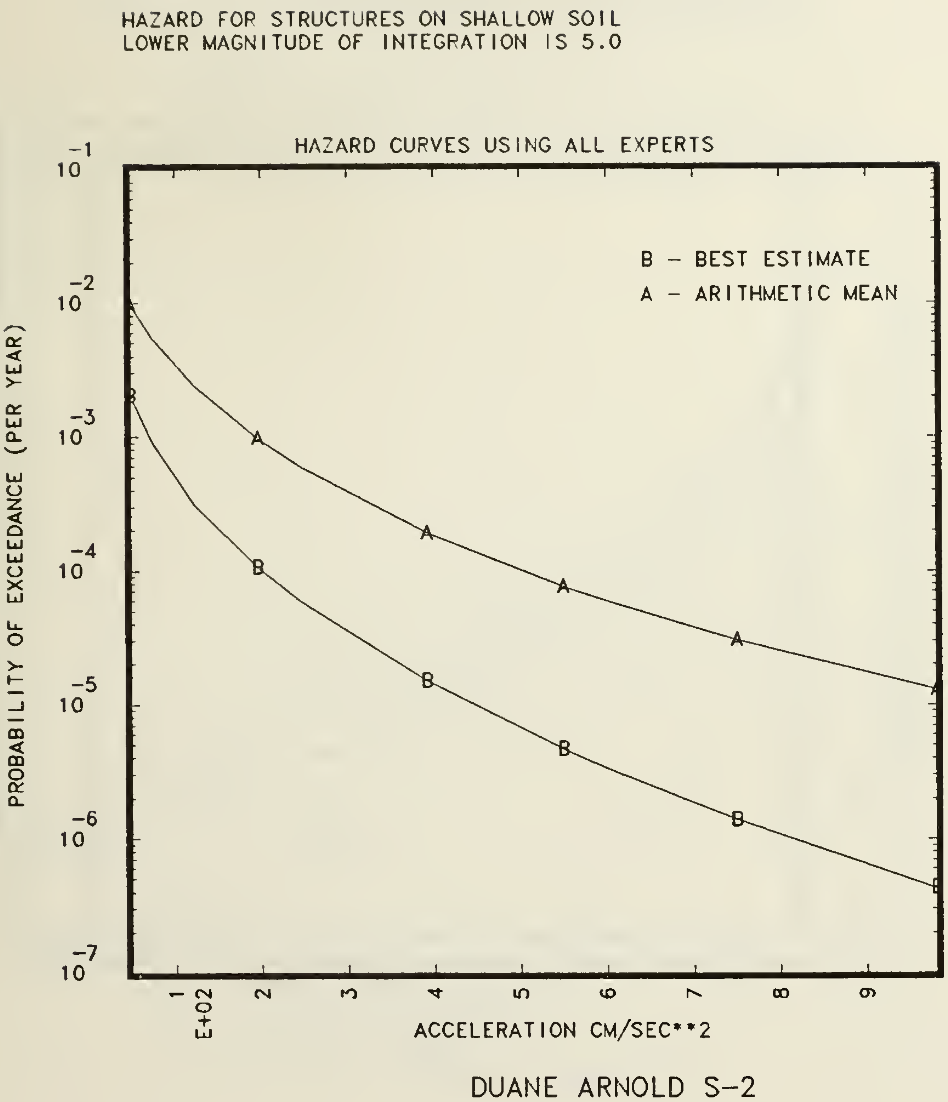


Figure 2.12.1 Comparison of the BEHC and the AMHC applicable for the structures founded on shallow soil aggregated over all S and G-Experts for the Duane Arnold site.

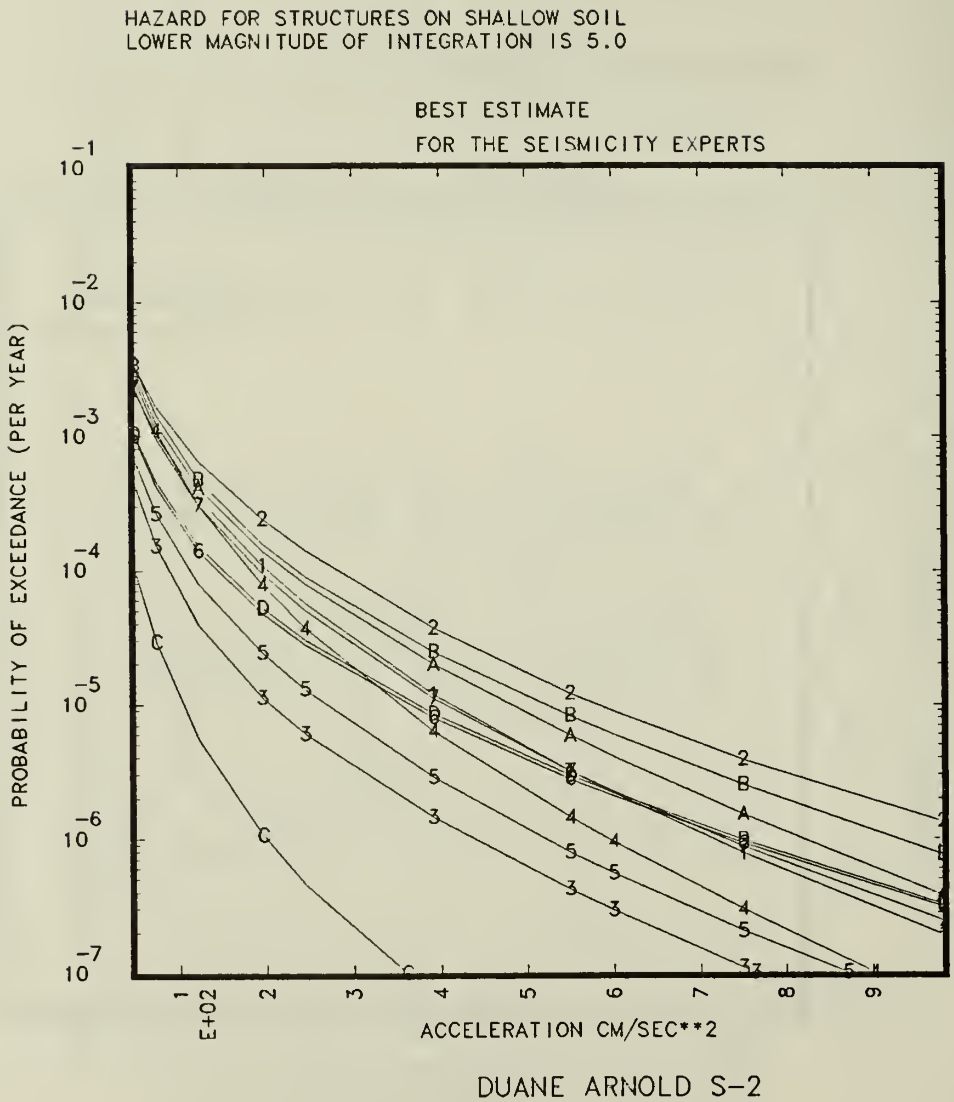


Figure 2.12.2 BEHCs applicable for the structures founded on shallow soil per S-Expert combined over all G-Experts for the Duane Arnold site. Plot symbols given in Table 2.0.

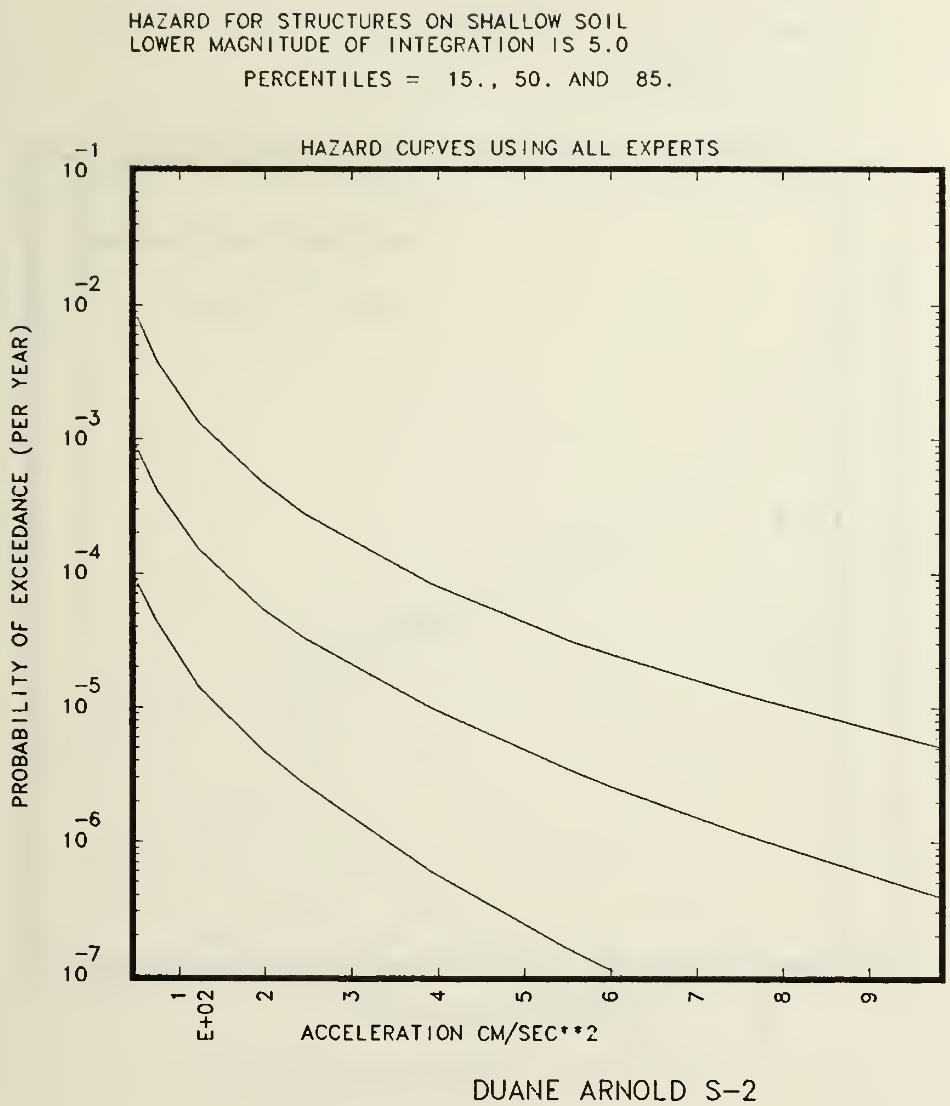


Figure 2.12.3 CPHCs for the 15th, 50th and 85th percentiles applicable for the structures founded on shallow soil based on all S and G-Experts' input for the Duane Arnold site.

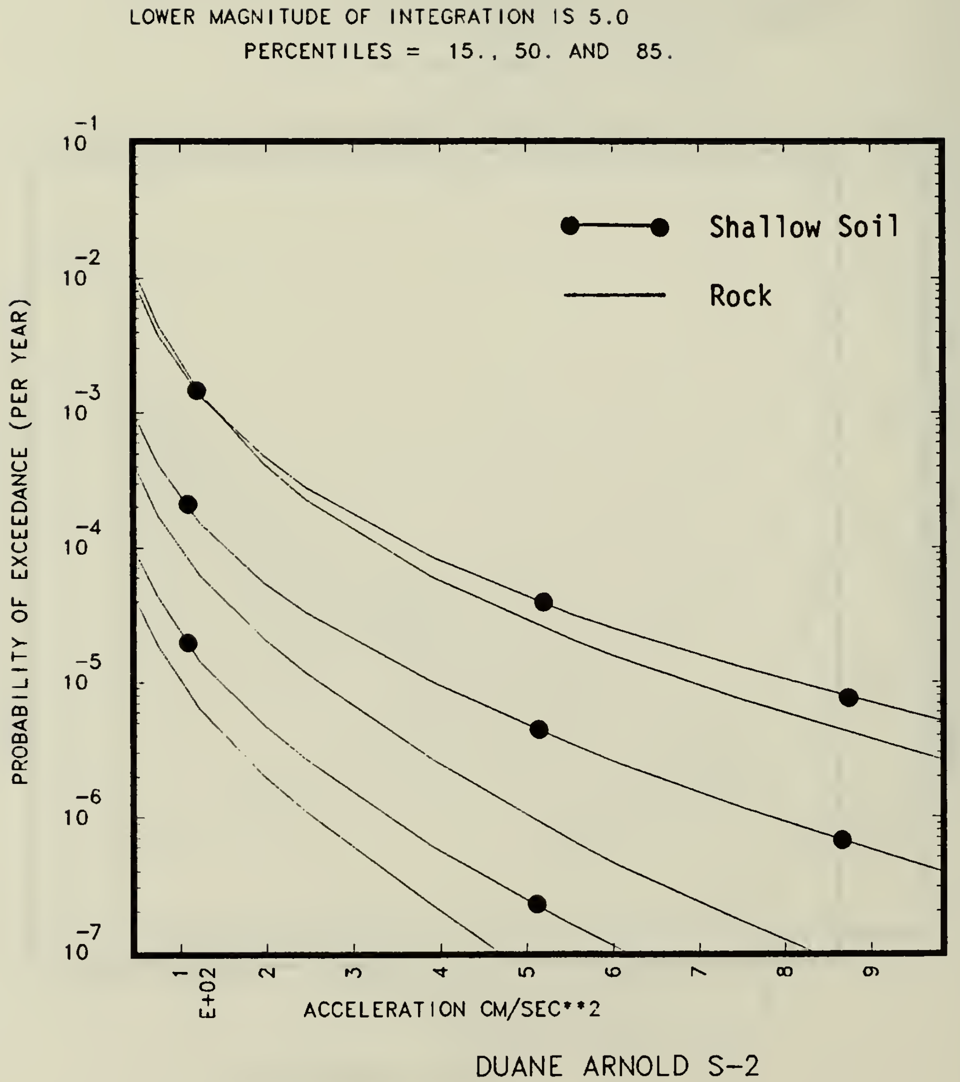


Figure 2.12.4 Comparison between the CPHCs for the secondary soil category given in Table 1.1 and the rock case for the Duane Arnold site.

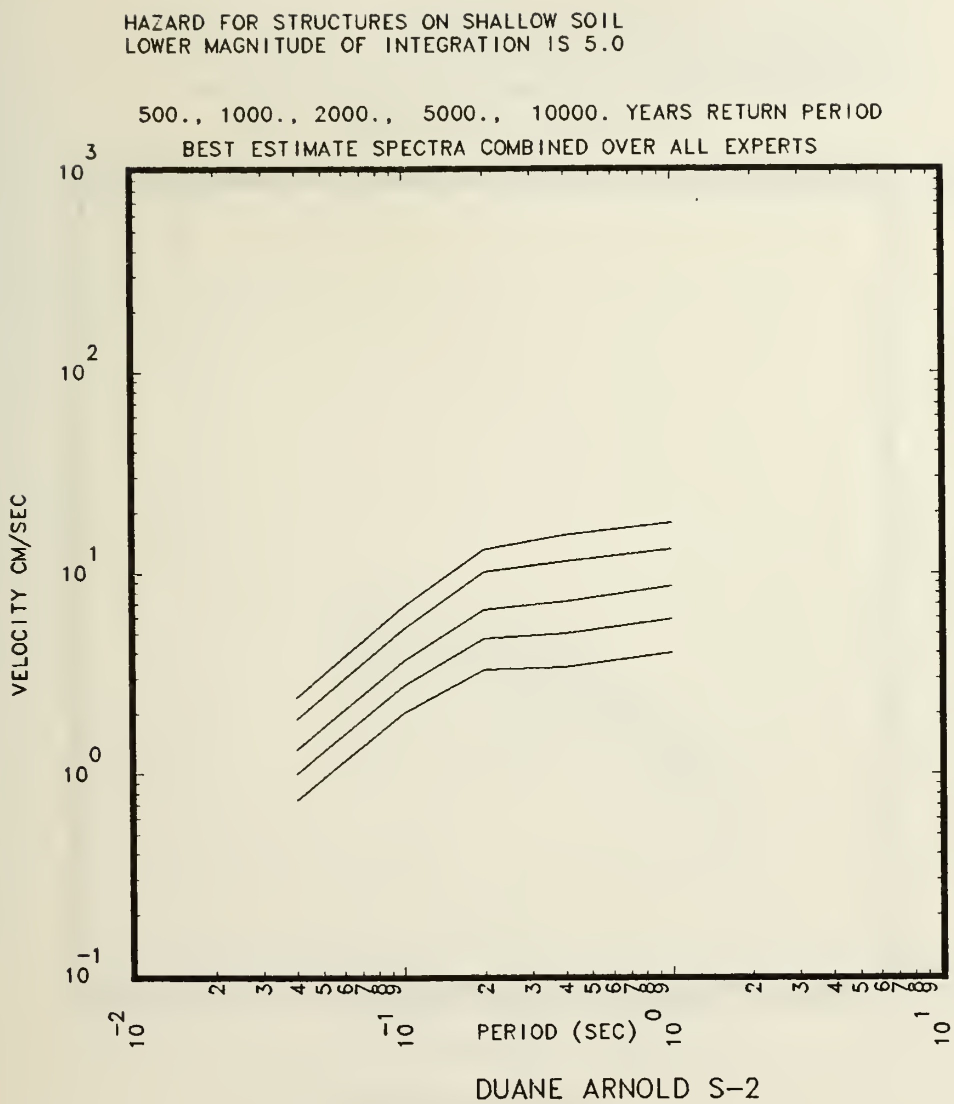


Figure 2.12.5 BEUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years aggregated over all S and G-Experts for the Duane Arnold site.

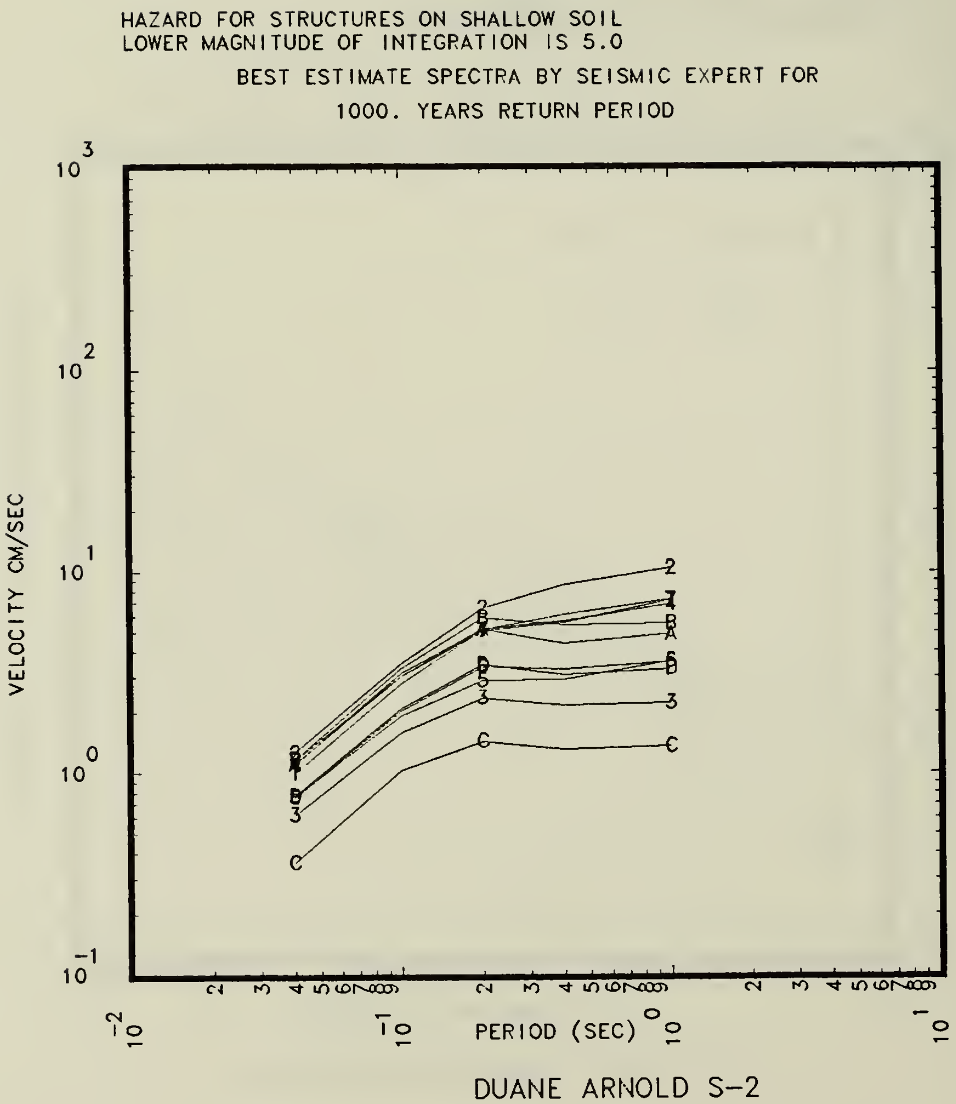


Figure 2.12.6 The 1000 year return period BEUHS applicable for the structures founded on shallow soil per S-Expert aggregated over all G-Experts for the Duane Arnold site. Plot symbols are given in Table 2.0

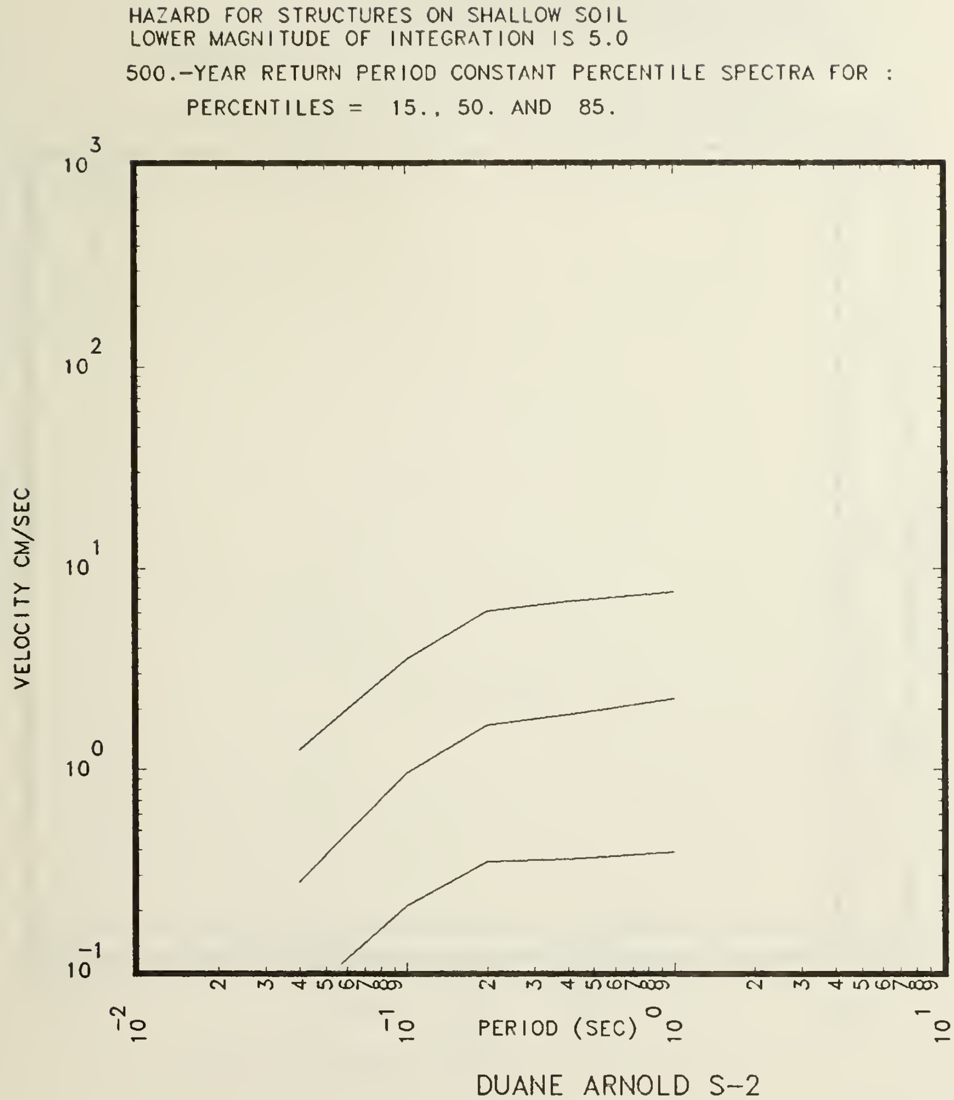


Figure 2.12.7 500 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentiles aggregated over all S and G-Experts for the Duane Arnold site.

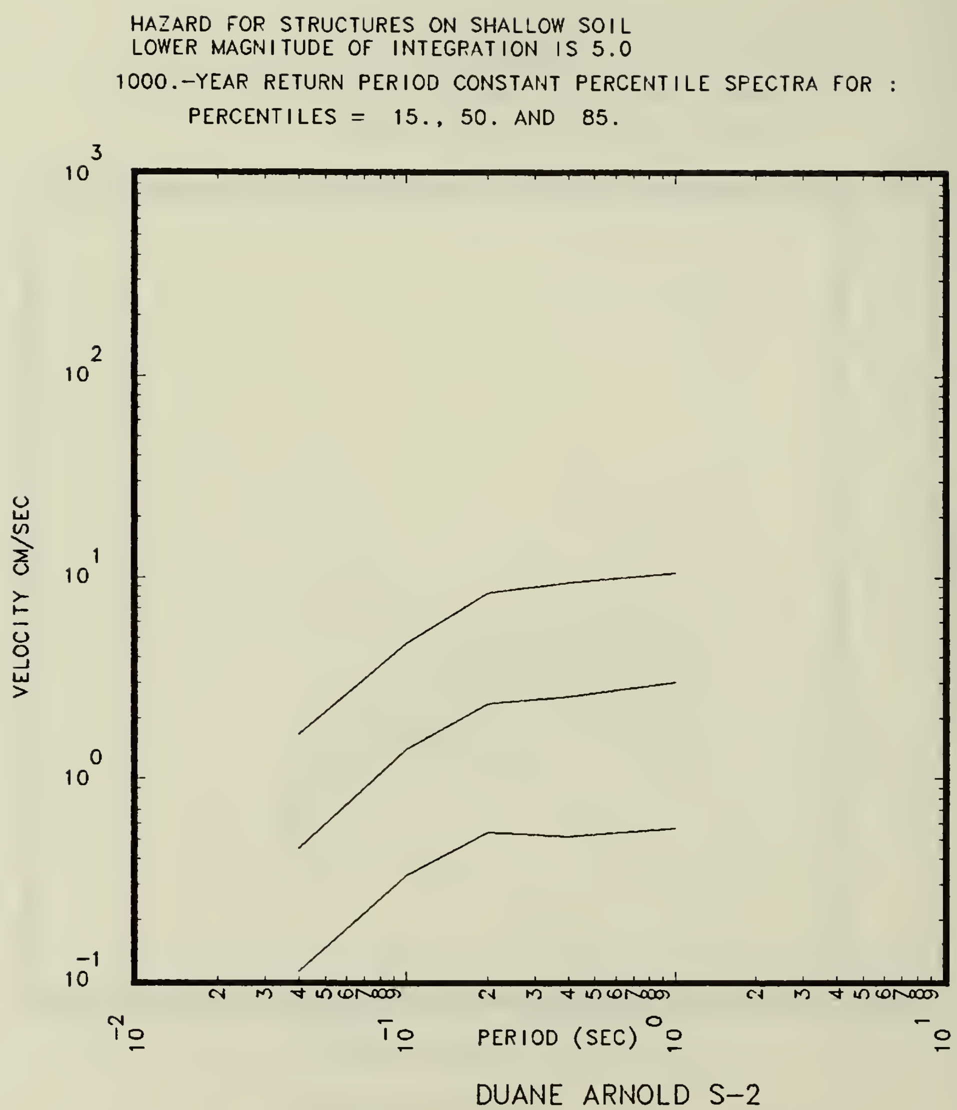


Figure 2.12.8 1000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Duane Arnold site.

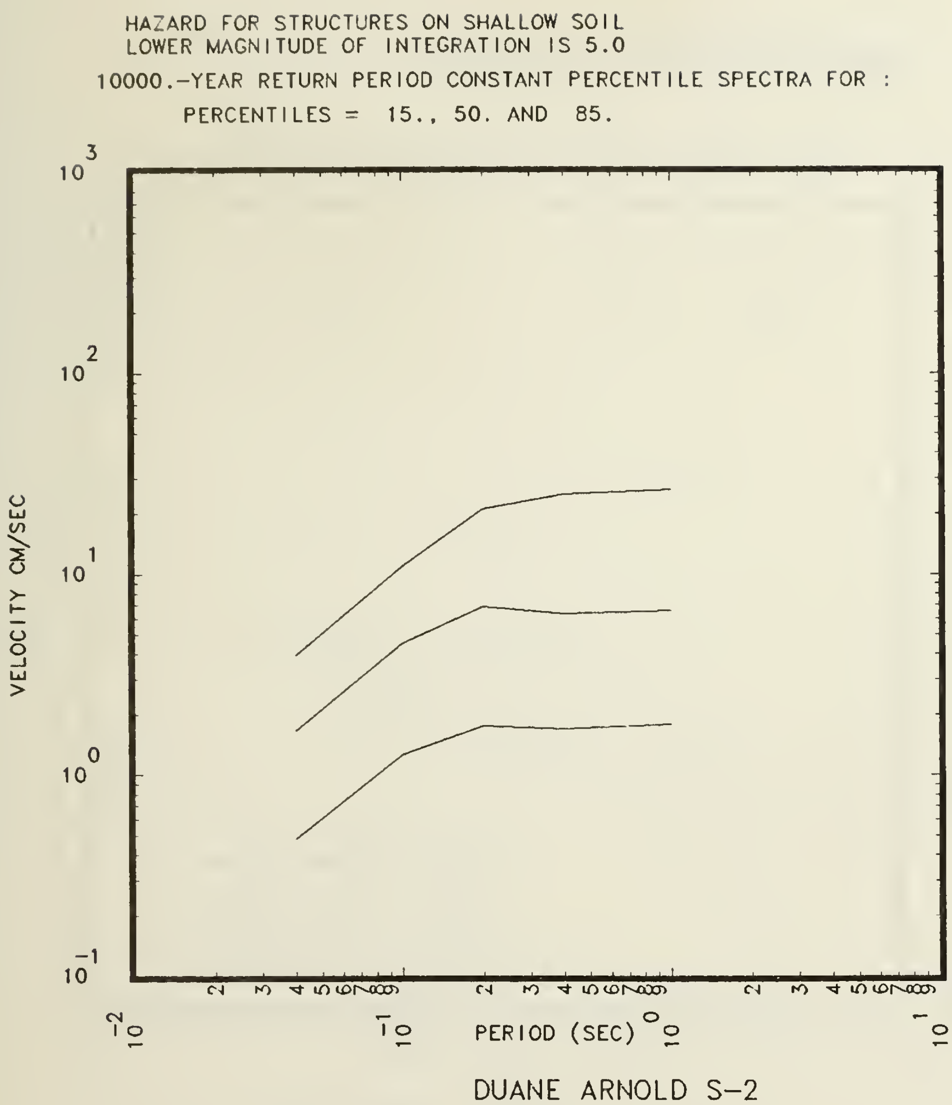


Figure 2.12.9 10000 year return period CPUHS applicable for the structures founded on shallow soil for the 15th, 50th and 85th percentile aggregated over all S and G-Experts for the Duane Arnold site.

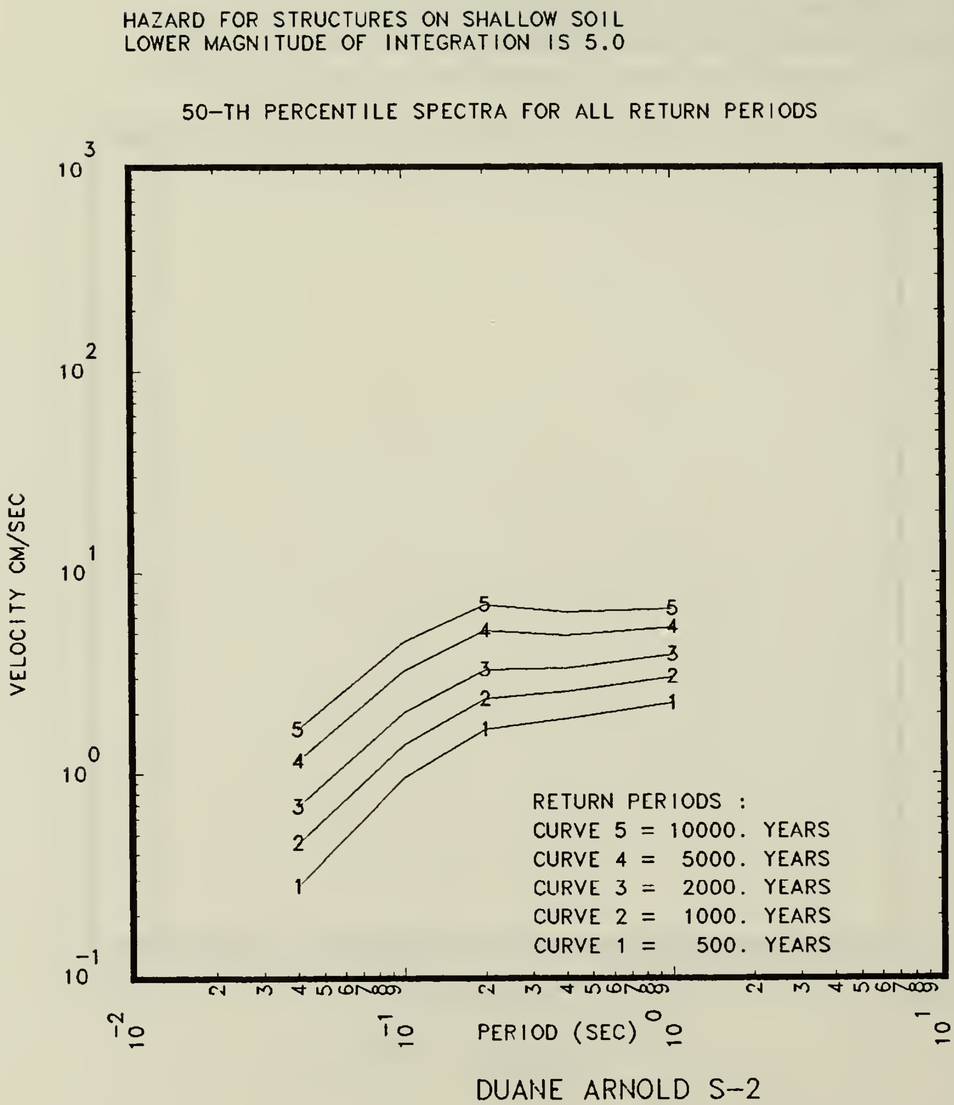


Figure 2.12.10 Comparison of the 50th percentile CPUHS applicable for the structures founded on shallow soil for return periods of 500, 1000, 2000, 5000 and 10000 years for the Duane Arnold site.

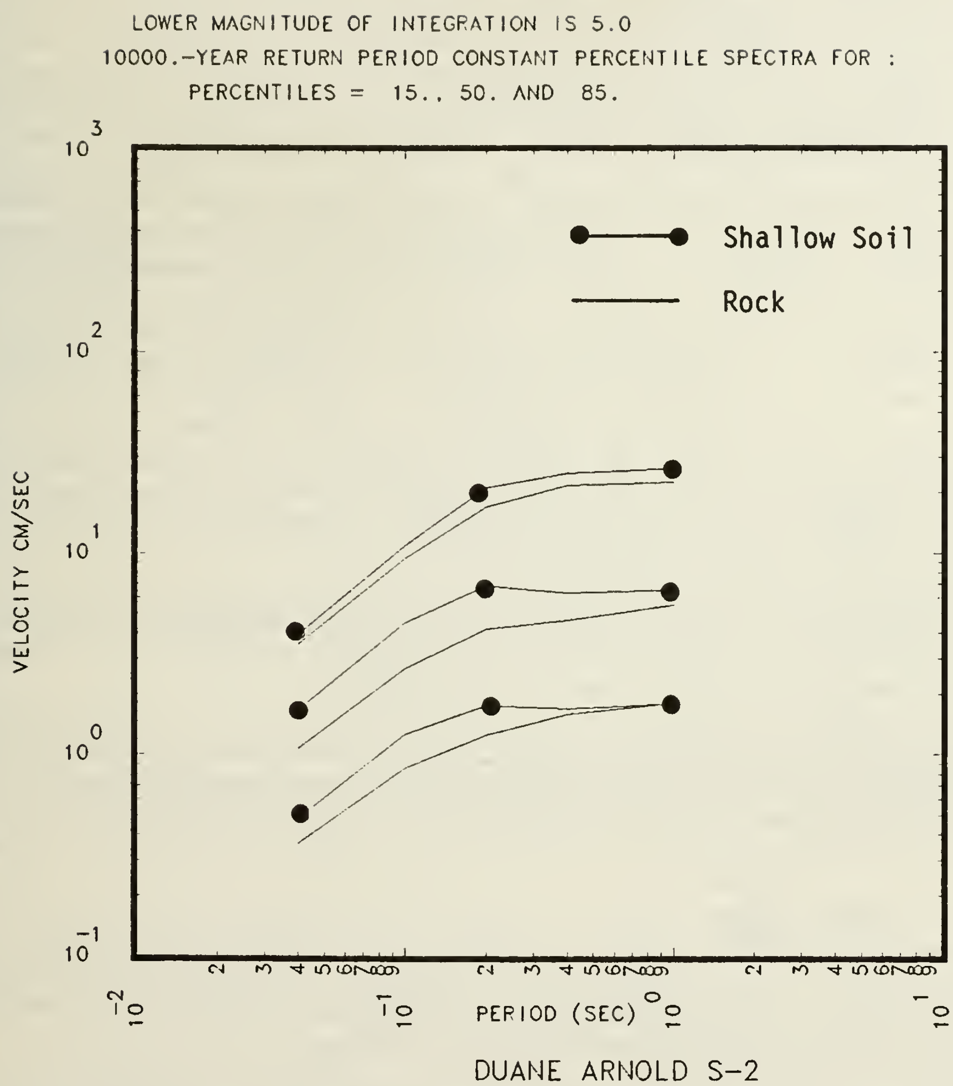


Figure 2.12.11 Comparison between the 10000 year return period 15th, 50th and 85th percentile for the shallow soil case and the rock case for the Duane Arnold site.

3.0 DISCUSSION AND CONCLUSIONS

3.1 Regional and Site-to-Site Variation

In Section 2.2 of Vol. VI we explored the regional (site-to-site) variation of the computed CPHCs between the rock base case and the various soil categories defined in Section 3.7 of Vol. I. Our approach in Vol. VI was to pick one site (Limerick) and examine the effect of changing the sites soil category on the computed CPHCs and CPUHS. Then we compared the results of this sensitivity study to the results obtained at three pairs of sites with different soil categories each pair being made up of two sites "close" to each other. See Table 2.2.2 of Vol. VI. We concluded, on the basis of these comparisons, that there did not appear to be a large regional or site-to-site variation between the rock and shallow soil categories for the computed median CPHCs and CP HS. The results given in Section 2 of this report are at odds with the conclusion reached in Vol. VI when the comparison is made on the basis of probabilities of exceedance for a given ground motion value (i.e., PGA). For example, in Fig. 3.1.1 we plot, and in Table 1.1 we give, the ratio between the median probability of exceeding 0.3g for the shallow soil case to the rock case for the twelve sites contained in this volume. We see from Table 1.1 and Fig. 3.1.1 that the ratio of probabilities of exceedance for a fixed PGA (for just the sites that fall into the Sand-1 soil category) varies between 2.4 to over 5. In Vol. VI our results suggested a ratio of approximately 2.5 (see Fig. 2.2.10 of Vol. VI).

However, it is easier to understand the behavior of the results when the parameter of interest is the ground motion parameter itself (i.e., the PGA or PSRV) rather than the probabilities of exceedance.

Let us first examine the ratios, r(p), of PGA between the shallow soil $a_s(p)$ to the rock case $a_r(p)$ for three different but fixed probabilities of exceedance (p) equal to 10^{-3}, 10^{-4} and 10^{-5}. r(p) is defined by:

$$r(p) = \frac{a_s(p)}{a_r(p)}$$

The values of $a_s(p)$ and $a_r(p)$ reported in Table 3.1.1 are taken from the Fig. 2.SN.4 of Vol. VIII for each of the 12 sites.

Recall that there are two types of site corrections being applied in this analysis (see Vol. I Section 3.7).

- o One type of correction is the simple correction advocated by G-Expert 5, for which the median correction factor shallow soil/rock is approximately equal to 0.73 (see left side of Fig. 3.10 in Vol. I) regardless of the specific shallow site category.

- o The other type of correction, advocated by the other 4 G-Experts, is the categorized correction for which the ratios (shallow/rock) depend on the

soil category (see left sides of Figs. 3.12 and 3.13 of Vol. I) and are equal to:

Sand-1/Rock: r=1.65
Till-1/Rock: r=1.55
Till-2/Rock: r=1.38

Thus if the only ground motion input used were that of G-Expert 5, we would expect the average correction factor r(p) to be always approximately 0.73.

Furthermore, if G-Expert 5's input were not used, we would expect the average ratio shallow/rock to be 1.65 when the shallow soil is in category Sand-1, 1.55 if it is in category Till-1, and 1.38 if it is in category Till-2.

Since the results presented here used input from all the G-Experts in a proportion approximately of 1/5 weight for each of them, we would expect, on the average, the ratios r(p) to be equal to:

(.73)(.20) + (1.65)(.80) = 1.47 for Sand-1/Rock
(.73)(.20) + (1.55)(.80) = 1.39 for Till-1/Rock
(.73)(.20) + (1.38)(.80) = 1.25 for Till-2/Rock

Column (7) of Table 3.1.1 gives for each of the 12 sites of Table 1.1 the expected approximate ratio if G-Expert 5 were not used, column (6) shows the expected ratio if only G-Expert 5 were used, column (5) gives the expected approximate ratio if all G-Experts were weighted equally, and the next column (4) gives the average of the ratios shallow/rock given in columns (1), (2) and (3). Columns (1), (2) and (3) give the r(p) values for the probabilities of exceedance 10^{-3}, 10^{-4} and 10^{-5}.

Table 3.1.1 shows clearly that the effective correction factors (column (4)), which are obtained as an average of correction factors for three given probabilities of exceedance, are in general very close to the approximate values one would expect if the ground motion experts choices of correction were weighted equally (compare columns (4) and (5) in Table 3.1.1).

The deviation from the value in column (5) is due to the complex interaction between ground motion models and seismicity zones, seismicity parameters and the fact that the correction factor is not deterministic but is defined by a probability distribution. Depending on all those factors the impact will be that the correction advocated by G-Expert 5 will have more or less weight, relative to the other 4 experts. For Oconee, the combination of the above mentioned interactions leads to an impact of G-Expert 5 greater than the equal weight case. For the other sites, but Three Mile Island and North Anna, the effect is reversed and the opinion of G-Expert 5 appears to be more diluted than in the equal weight case.

For Three Mile Island and North Anna neither group (i.e., with or without G-Expert 5) seems to dominate.

The case of Arkansas, Callaway and Duane Arnold requires additional scrutiny. For those three sites, Table 3.1.1 shows that the effective

amplification factors (column (4)) obtained in our simulation are close to the case when Expert 5's model is not used (compare column (4) with column (7)).

This phenomenon seems extreme and can be explained as follows, (remembering that we are comparing median hazard curves for rock and for soil):

- For the rock case, the contribution to the hazard comes from distant large earthquakes. Figure 3.4 of Vol. I shows that in that range, G-Expert 5's ground motion model (number 3 on Fig. 3.4-Vol. I) is much higher than the rest of the models. Thus, the resultant median value is more representative of the other four ground motion models.

- For the shallow soil case, the large, distant earthquakes are also dominant, and G-Expert 5's model falls within the cluster of other models, thus, the median will be representative of all the models, and in particular again close to the median without Expert 5.

The result is that the final ratio of PGA between shallow and rock cases for these three sites is close to the case when only the categorized correction is used (i.e., the correction recommended by all but G-Expert 5).

Prior to drawing some conclusions, let us define the meaning of the term "correction" of the hazard curve. Let us assume that the hazard curve for a rock site is known, and one needs to have an estimate of the hazard at the same location but for a shallow soil condition. If one assumes the amplification from rock to soil to be a constant multiplicative value (say r_c), then one would generate rigorously the soil hazard curve by taking each point of the rock hazard curve, say acceleration a_R for a probability of exceedance h, and derive the corresponding point, a_S, for the same probability of exceedance h, of the soil hazard curve such that

$$a_S = a_R \cdot r_c \qquad \text{at constant h.}$$

Although this operation is correct for a constant r_c as indicated above, it would not be correct to perform it when a combination of correction types are used as in our study where the final effect is in between the two types of corrections as indicated in Table 3.1.1, and the relative weight of each type of correction depends both on the dominant zonation effects and on the dominant ground motion models.

However, Table 3.1.1 shows that constructing a soil hazard curve by first starting from our rock hazard curves and applying an average correction factor would lead to an estimated soil hazard curve close to the hazard curve estimated by our full method described in Vol. I and Section 2.2 of this volume.

Table 3.1.1 shows that the error could be negligible in some cases, and at most, for the 12 sites considered here, the error would have been 13% (for Callaway). In all 12 cases but one (i.e., Oconee), the error would have been an underestimation (it would have been overestimated by approximately 3% at Oconee).

At the present time, we have not been able to derive any simple correlation between this effective amplification factor (column (4) of Table 3.1.1) and the zonation characteristics, location, soil conditions, or any other parameters specific to any given site, thus making impossible the rigorous transformation of our rock hazard curves into soil hazard curves in a simple way.

And finally, one needs to caution the reader in extending the above conclusions to the probability of exceedance space. In spite of the remarkable stability of the correction factors shown in Table 3.1.1, Fig. 3.1.1 shows a quite different effect. Figure 3.1.1 shows the ratios as a function of both the average slopes of the hazard curves (soil and rock hazard curves) and the average amplification from rock to soil. If all sites exhibited exactly the same rock hazard curves, then Fig. 3.1.1 would be an exact representation of column (4) of Table 3.1.1. However, the slopes of those hazard curves are not exactly the same as 0.2g, thus Fig. 3.1.1 shows some deviation from column (4) of Table 3.1.1. The general shape of Fig. 3.1.1 is representative of the overall process and can be considered as some sort of a signature.

If some elements of the zonation, seismicity or ground motion models were to be changed, Fig. 3.1.1 would change. In a sensitivity test, we removed ground motion Experts' 5 input and found that Fig. 3.1.1 was slightly changed but its general shape and level were preserved.

We feel confident that the effects shown in Table 3.1.1 and Fig. 3.1.1 are realistic representations of the physical effects given our assumptions on the site correction methods, and not due to some unexpected parasitic software or numerical problems such as the choice of number of simulation, for we have performed numerous tests in previous studies to validate our operating parameters (Bernreuter et al., 1985).

TABLE 3.1.1

RATIOS OF PGA VALUES BETWEEN SHALLOW AND ROCK CONDITIONS FOR FIXED VALUES OF THE HAZARD

Site	Soil Category	Ratio Shallow/Rock 10^{-3} (1)	10^{-4} (2)	10^{-5} (3)	Avg. (4)	All Equal Weight (5)	Only G5* (6)	W/O G5** (7)
1 Nine Mile Point	Sand-1	1.57	1.58	1.59	1.58	1.47	0.73	1.65
2 Susquehanna	Till-2	1.30	1.30	1.30	1.30	1.25	0.73	1.38
3 Three Mile Island	Sand-1	1.50	1.47	1.44	1.47	1.47	0.73	1.65
4 Browns Ferry	Sand-1	1.56	1.66	1.68	1.63	1.47	0.73	1.65
5 Catawba	Sand-1	1.59	1.58	1.55	1.57	1.47	0.73	1.65
6 Farley	Sand-1	N/A	1.56	1.49	1.53	1.47	0.73	1.65
7 North Anna	Sand-1	1.51	1.50	1.51	1.51	1.47	0.73	1.65
8 Oconee	Sand-1	1.37	1.44	1.47	1.43	1.47	0.73	1.65
9 Summer	Sand-1	1.47	1.62	1.61	1.57	1.47	0.73	1.65
10 Arkansas	Till-1	1.51	1.50	1.50	1.50	1.39	0.73	1.55
11 Callaway	Sand-1	1.65	1.70	1.72	1.69	1.47	0.73	1.65
12 Duane Arnold	Till-1	N/A	1.50	1.50	1.50	1.39	0.73	1.55

* Ratio of PGA shallow/rock given by G-Expert 5 only
** Ratio of PGA shallow/rock given by G-Experts 1,2,3 and 4 only

3.2 Sensitivity to G-Expert 5's Model

In Section 3.2 of Vol. VI, as well as in the discussion of the results for a number of sites in Vol. II-V, we pointed out that the hazard at rock sites G-Expert 5's BEHC per S-Expert is significantly higher than the other G-Experts' BEHCs per S-Expert. We showed in Vol. VI that at rock sites if G-Expert 5's model was not included that there was a significant change in both the 85th percentile CPHCs and the AMHCs and a much smaller change in the median CPHCs. At soil sites the change in all three hazard curves (median, 85th percentile and AM) was much smaller (on the order of the size of the change in medians at rock sites).

Because of the sensitivity of the results to GM Expert 5's model, we examined the sensitivity of the correction for site category to including/not including G-Expert 5's model at both the Susquehanna and Browns Ferry sites. These two sites appear to span the range in the variation introduced by the site correction. In Table 3.2.1 we present the results of our sensitivity study. Table 3.2.1 gives the ratio of the probability of exceeding 0.3g between the shallow soil case and the rock case at the Browns Ferry and Susquehanna sites for median, 85th and AM estimators of the PGA for both the case when only G-Experts 1-4 are used and the case when all 5 G-Experts are used.

We see from Table 3.2.1 that the large variation in the ratio of the median probability of exceeding 0.3g shown in Fig. 3.1.1 and discussed in Section 3.1 holds even if G-expert 5's model is not included. This is interesting because, as discussed in detail in Vol. VI, one of the main reasons why G-Expert 5's model had such an impact on the hazard curves is the low attenuation of the model. At many sites, e.g., the Browns Ferry site, this low attenuation would make distant zones with larger magnitude earthquakes more significant than local zones. Based on the discussion given in Section 3.1, one might expect that if we did not include G-Expert 5's model the Browns Ferry site would become more like the Susquehanna site where the hazard is dominated by the zones near the site. The result of this would have been to lower the ratio of the median probabilities of exceeding 0.3g given in Table 3.2.1 from 5.1 to a value near 2 observed at the Susquehanna site. Clearly this did not happen, and in fact this ratio increased somewhat. At the Susquehanna site there was no change.

We see from Table 3.2.1 that including/not including G-Expert 5's model has a significant impact on the ratio of both the 85th and AM probabilities of exceeding 0.3g between the shallow soil and rock case at the Browns Ferry and Susquehanna sites. In general we expect that the difference between the 85th percentile CPHCs between the rock and soil cases when G-Expert 5's is not included will be similar, but somewhat larger, than the variation in the medians. The variation in the AMHCs between the rock and soil cases when G-Expert 5's model is not included will be larger than the variation in the 85th percentile CPHCs, and more variable from site to site.

However, when considering the ratios of acceleration for a given probability of exceedance, we found no change in the basic shape of Fig. 3.1.1, as explained in Section 3.1.

3.3 Conclusions

Our results show several interesting results:

- There can be a wide region-to-region and even site-to-site variation in how the site correction impacts the computed hazard at a site. We found that the computed median hazard applicable for the structures founded in shallow soil range over a factor of 2 to over 5 higher than the median hazard applicable for structures founded on rock at the same site. Given this wide variation and the complex set of factors causing this variation, it is not possible to say that our results include the worst case.

  However, in terms of PGA values for a fixed return period, we found that the values for the soil case fell within 13 percent of the value one would obtain by applying an effective amplification computed as the weighted G-Experts' amplification factors.

- Since such small variation in PGA can introduce large variations in the hazard estimate, it is clear from the results presented that it is not appropriate to correct for site conditions by first computing the hazard at a site by considering it as a rock site and then introduce approximate correction factors, e.g., such as could be extracted from the sensitivity results given in Section 2.2 of Vol. VI.

- Considerable caution must be exercised in trying to use the results given in this volume to extrapolate to other sites. There is a very complex interaction between the zonation, seismicity parameters and the correction for site type which has a significant impact on the computed hazard at any given site.

- The correction for site category is sensitive to the ground motion models used. If G-Expert 5's model is not included then it appears that there is a wider regional and site-to-site variation than when G-Expert 5's model is included.

TABLE 3.2.1

RATIO (SOIL/ROCK) OF THE PROBABILITY OF EXCEEDING 0.3g FOR THE CASE WHEN ALL 5 G-EXPERTS ARE USED AND THE CASE WHEN ONLY G-EXPERTS 1-4 ARE USED AT THE BROWNS FERRY AND SUSQUEHANNA SITES

	Browns Ferry		Susquehanna	
	All 5 G-Experts	Only G-Experts 1-4	All 5 G-Experts	Only G-Experts 1-4
Median	5.1	5.9	2.1	2.2
85th Percentile	1.4	6.9	1.1	2.8
AM	0.9	8.9	1.7	5.1

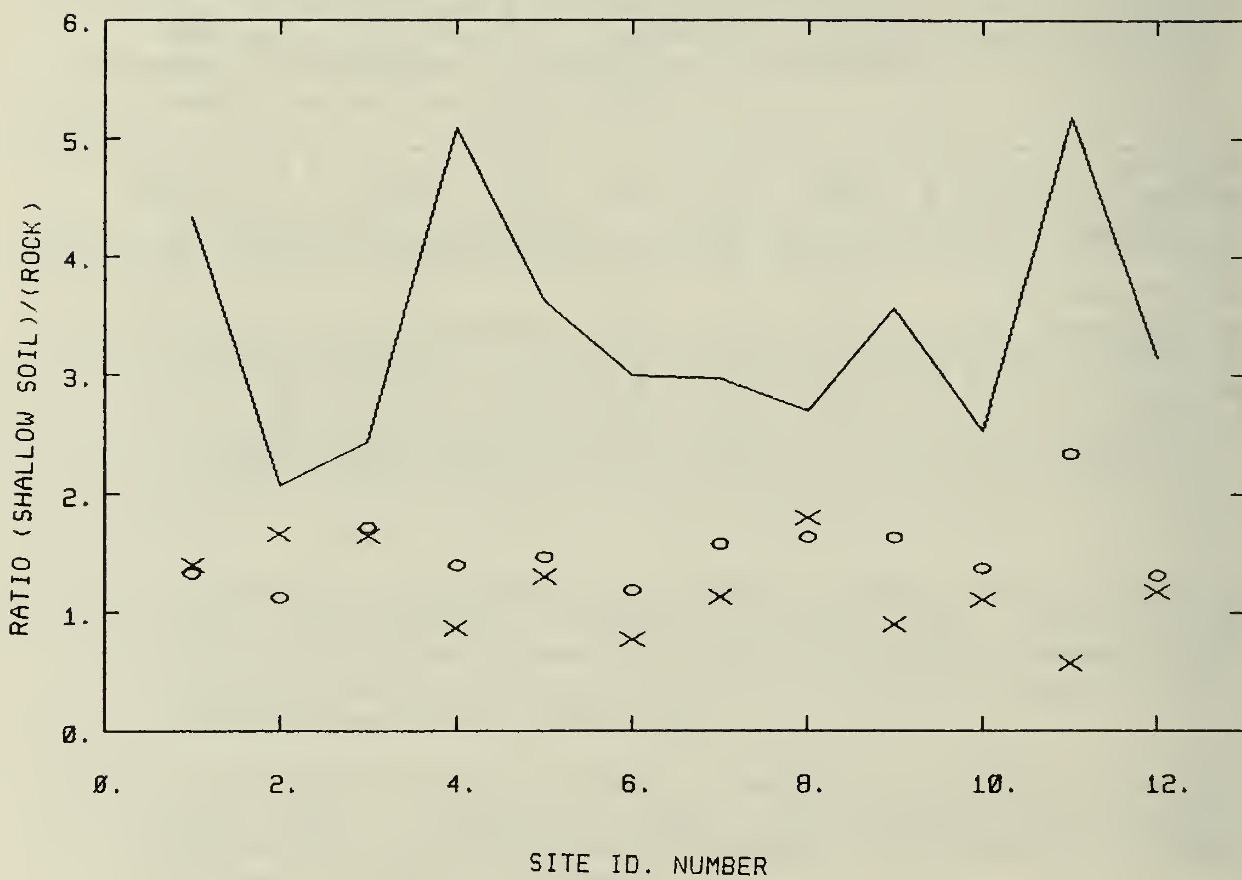


Figure 3.1.1 Plot of the ratio of the probability of exceeding 0.3g PGA for the median (line), 85th percentile (plot symbol, "O") and the arithmetic mean (plot symbol, "X") for the (shallow soil case)/(rock case). Site ID number is the same as the section number listed in Table 1.1.

APPENDIX A

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Appendix B

Maps of Seismic Zonation for Each of the 11 S-Experts

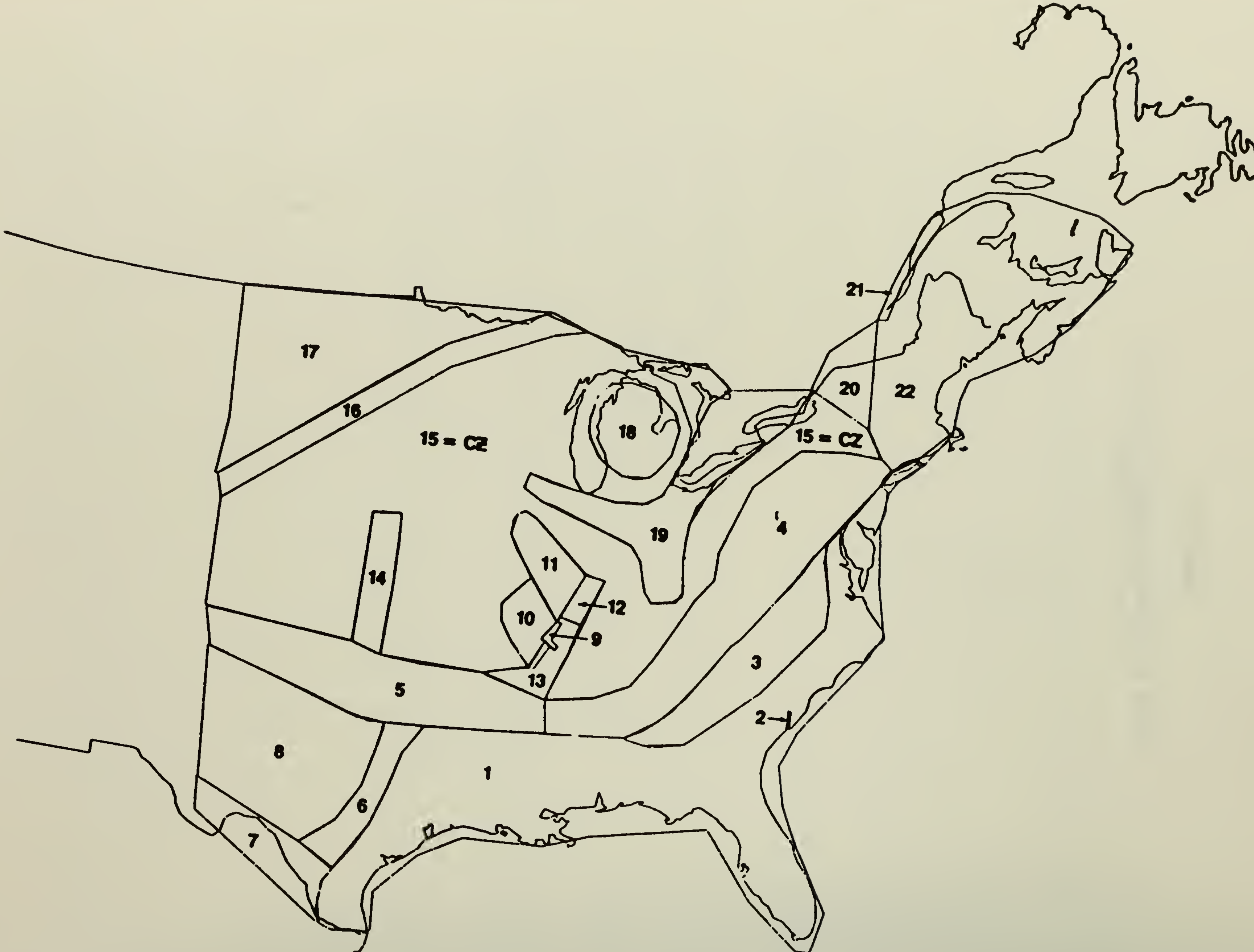

Figure B1.1 Seismic zonation base map for Expert 1.

Figure B1.2 Map of alternative seismic zonation to Expert 1's base map.

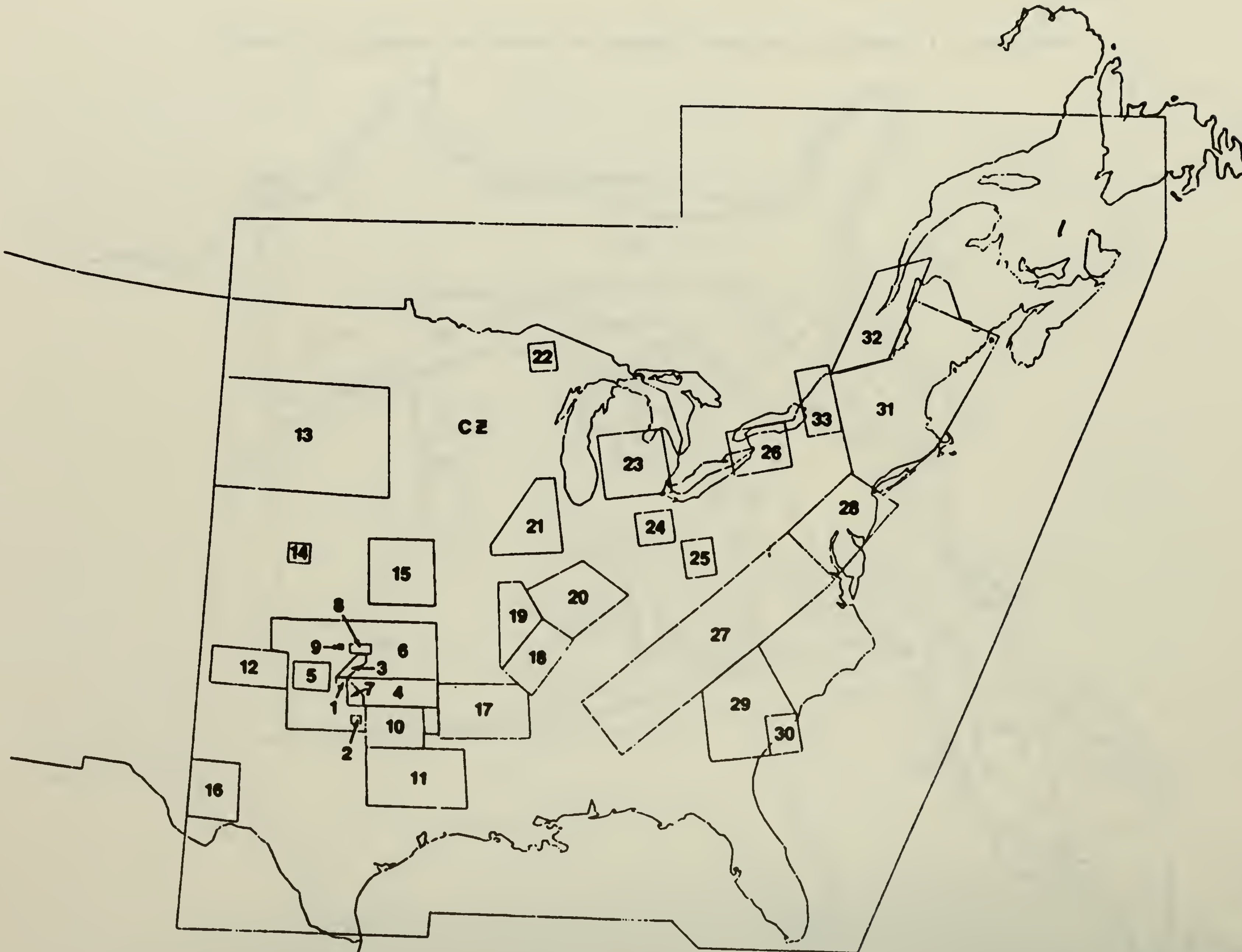

Figure B2.1 Seismic zonation base map for Expert 2.

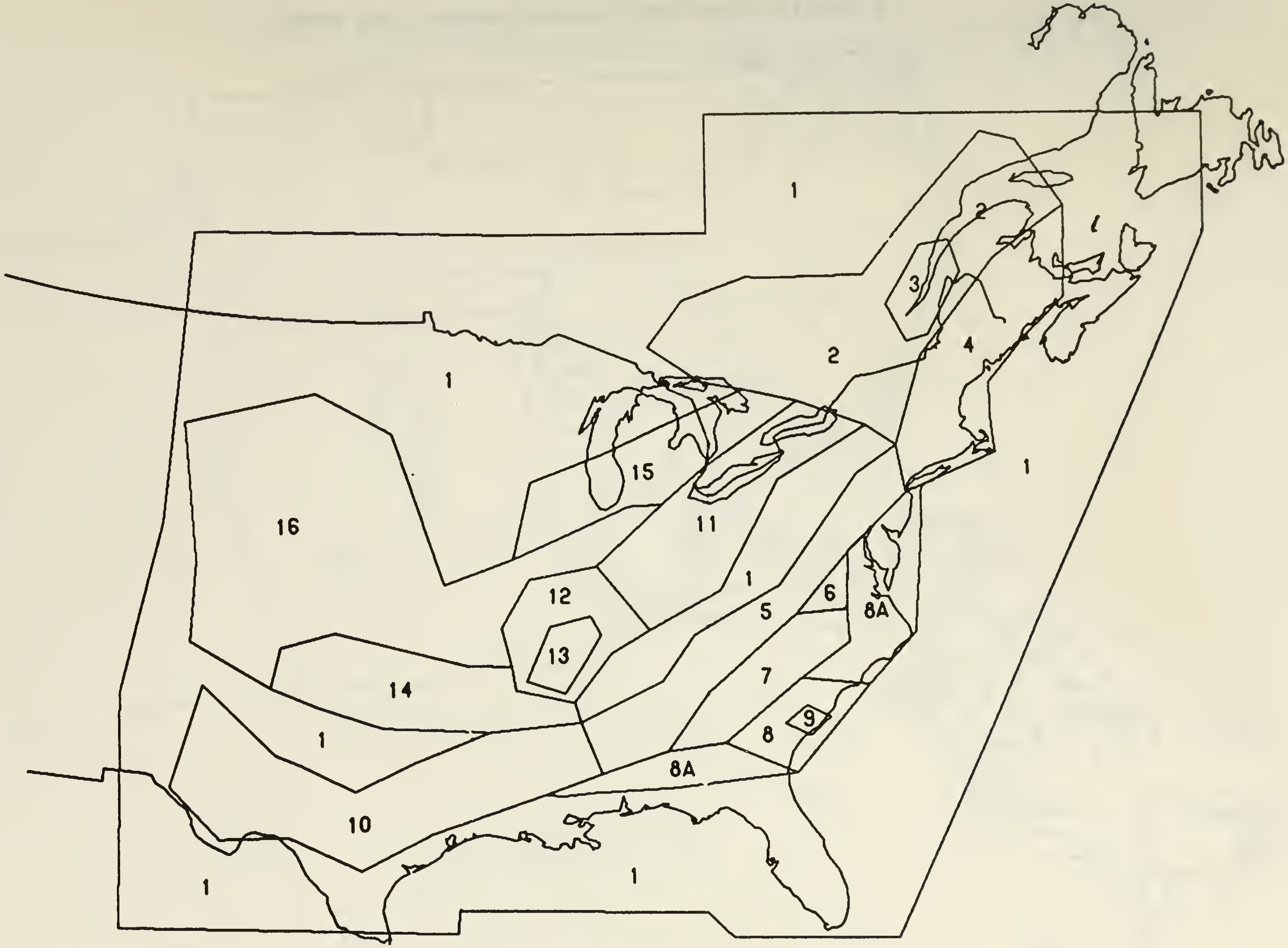

Figure B3.1 Seismic zonation base map for Expert 3.

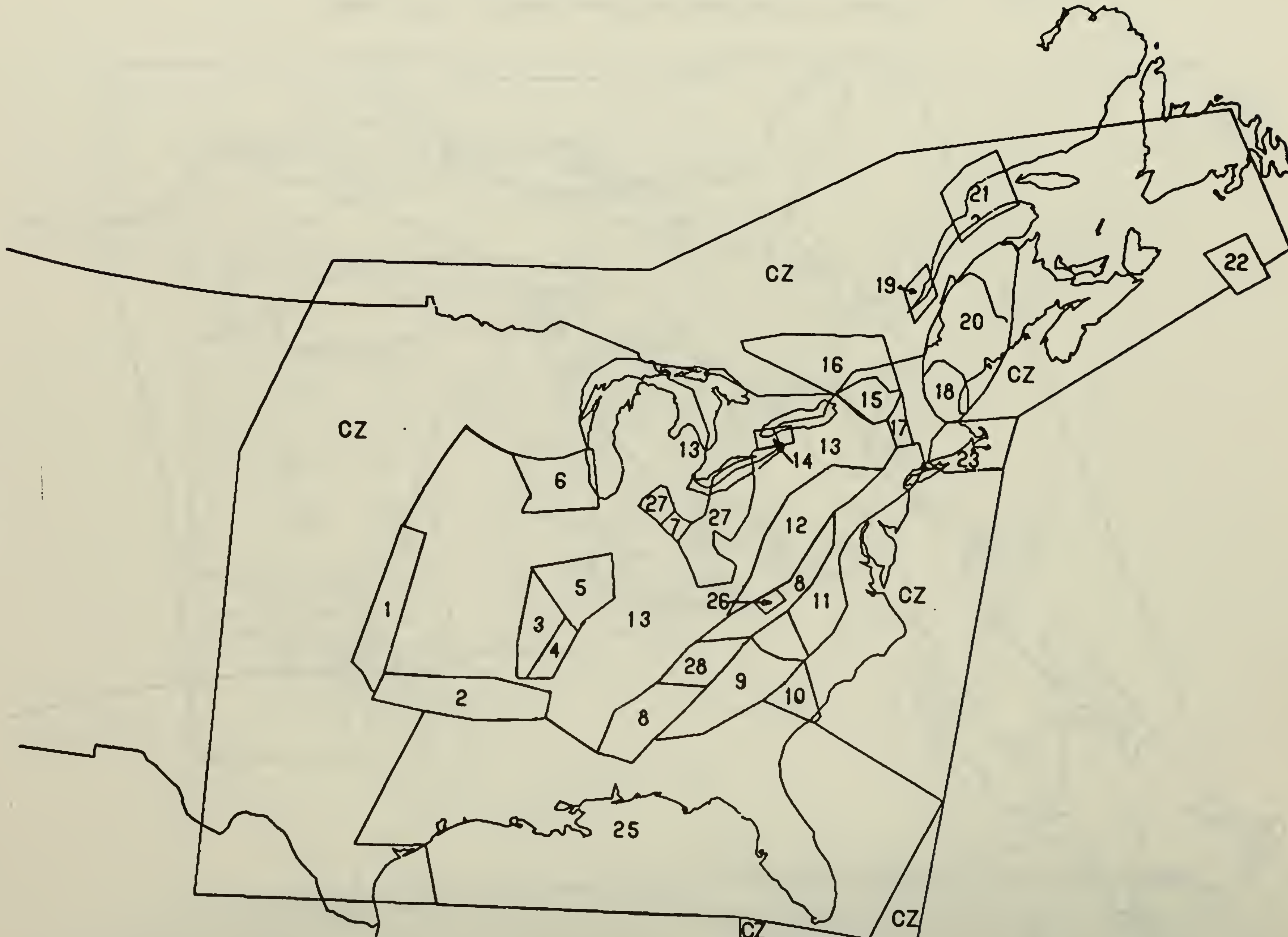

Figure B4.1 Seismic zonation base map for Expert 4.

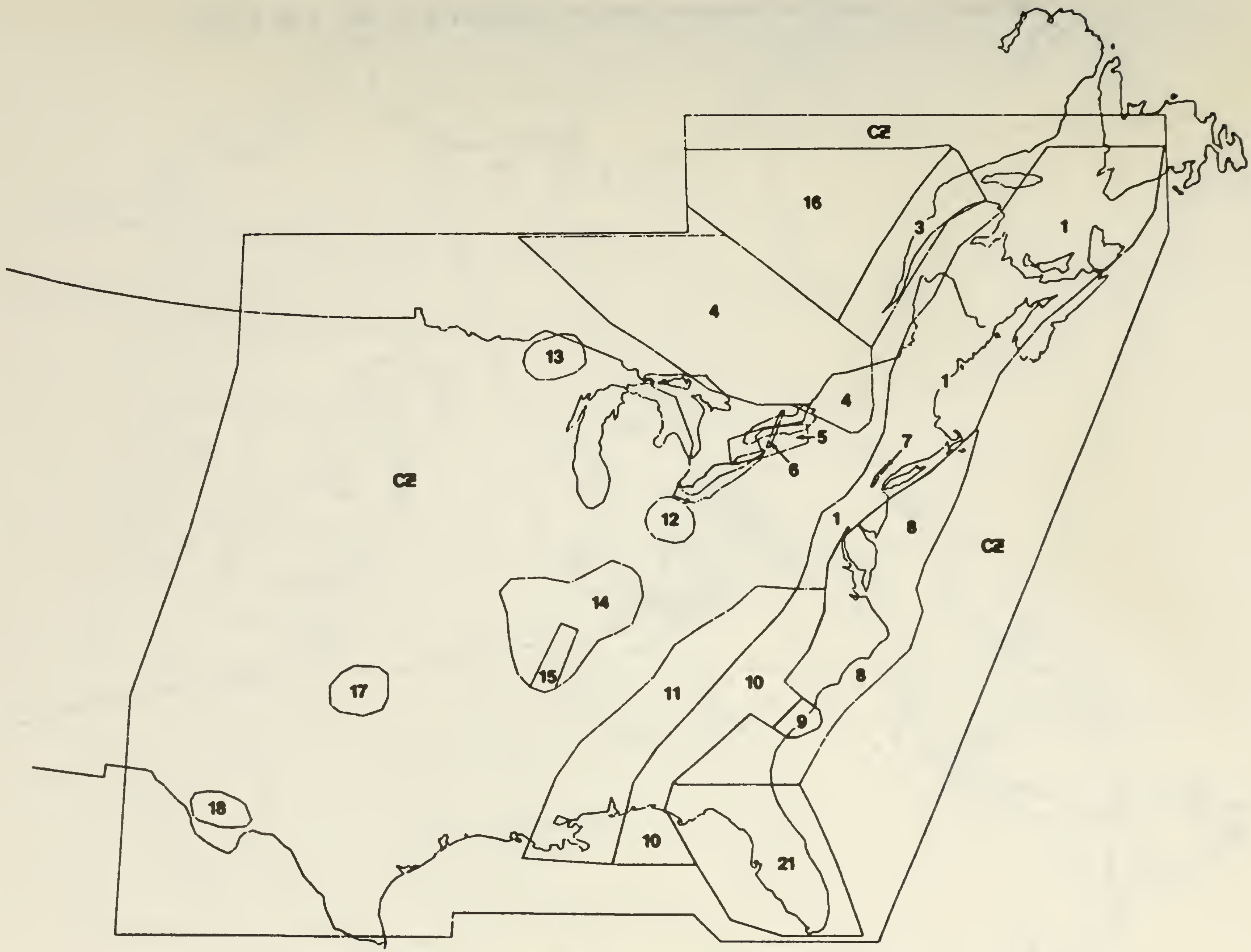

Figure B5.1 Seismic zonation base map for Expert 5

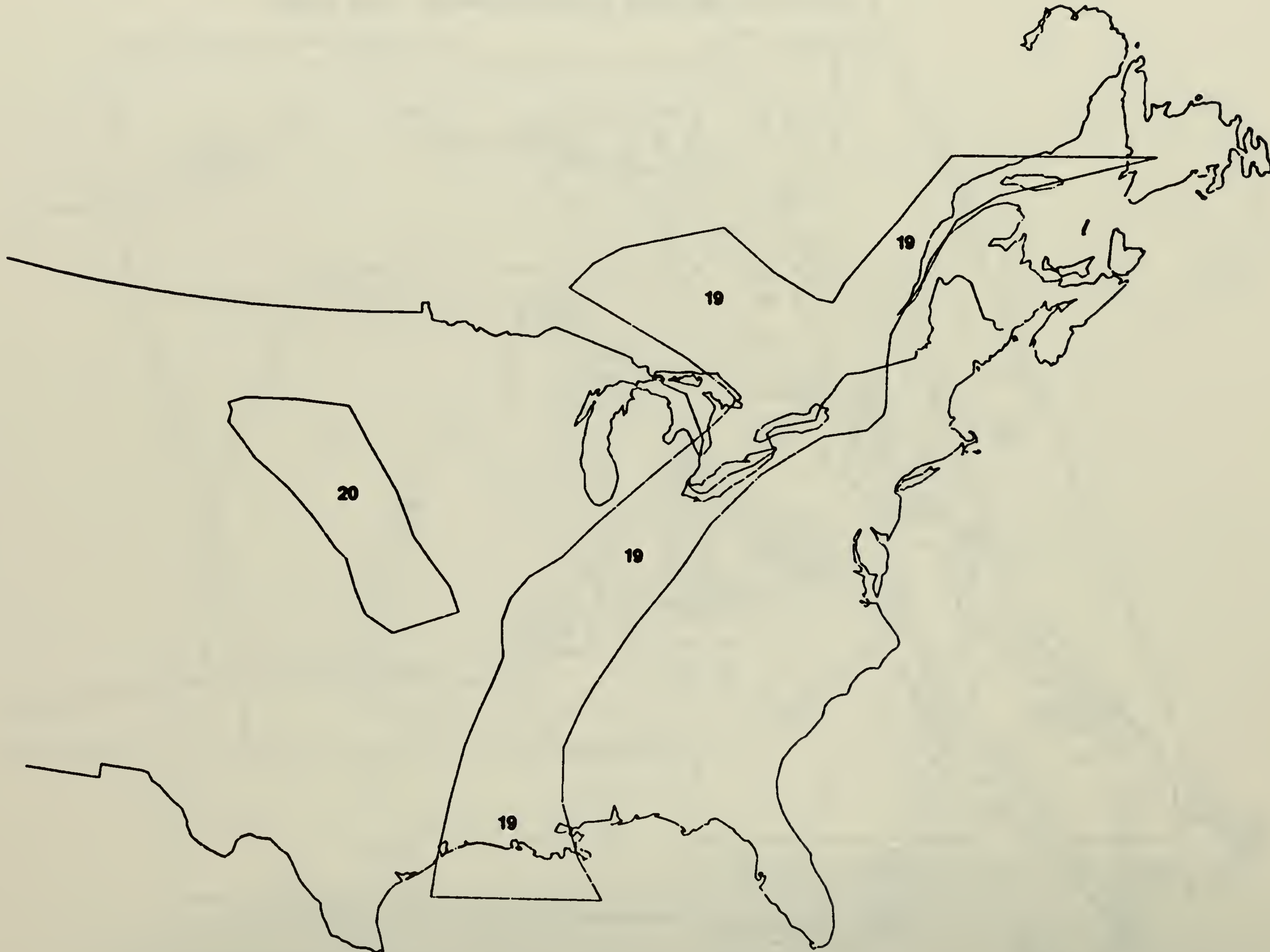

Figure B5.2 Map of alternative seismic zonations to Expert 5's base map.

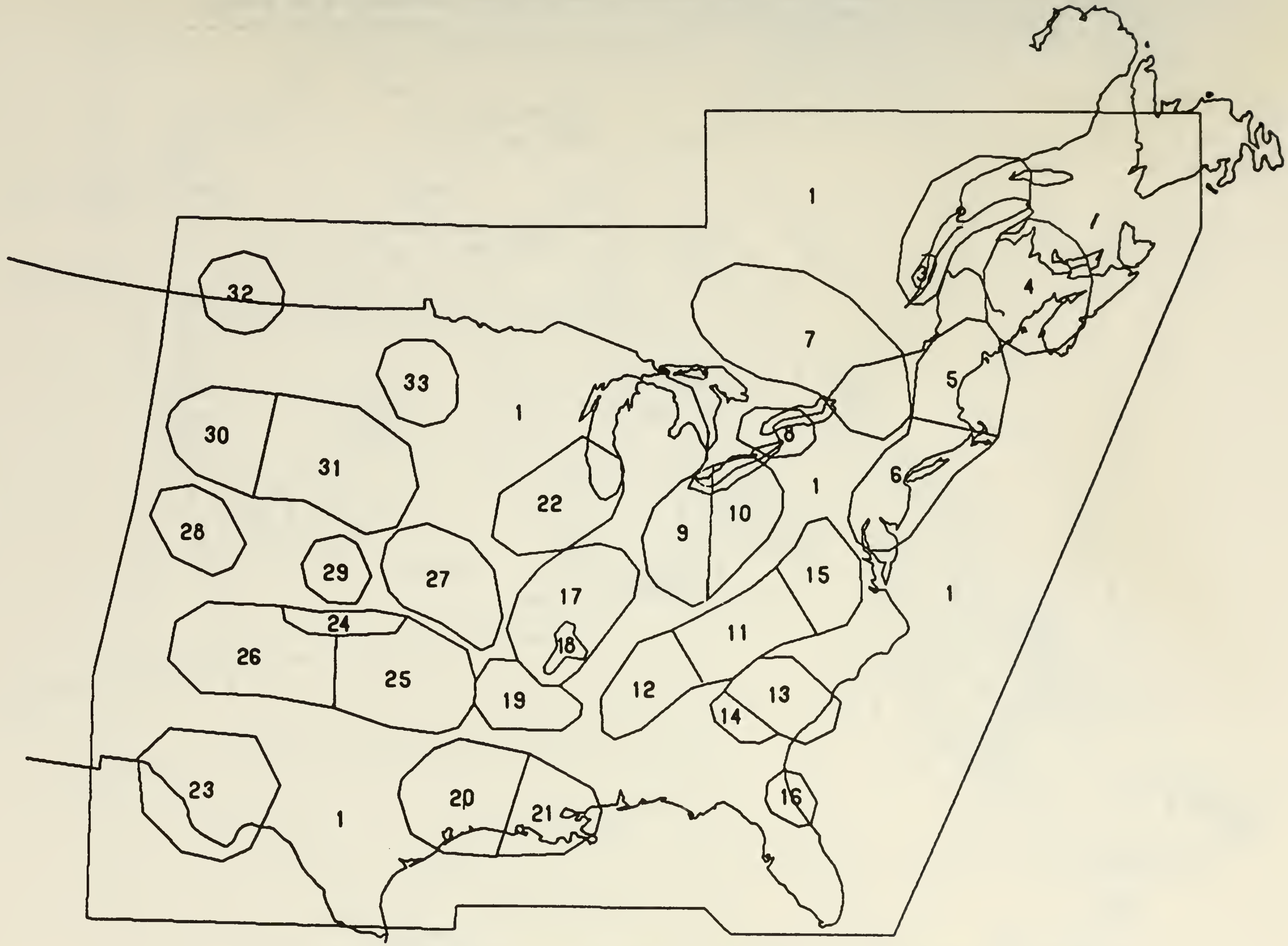

Figure B6.1 Seismic zonation base map for Expert 6

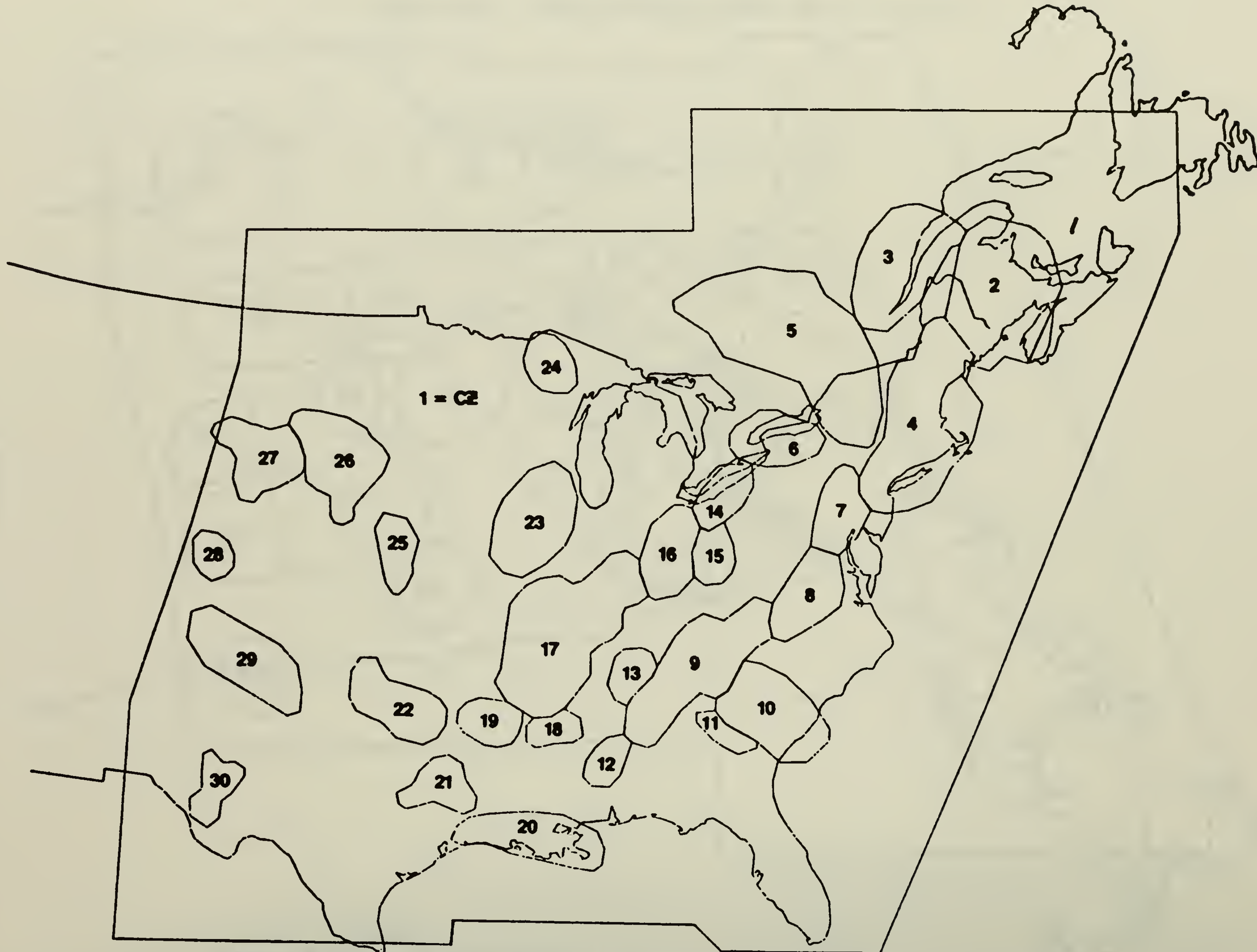

Figure B6.2 Seismic zonation map alternative 1 to Expert 6's base map.

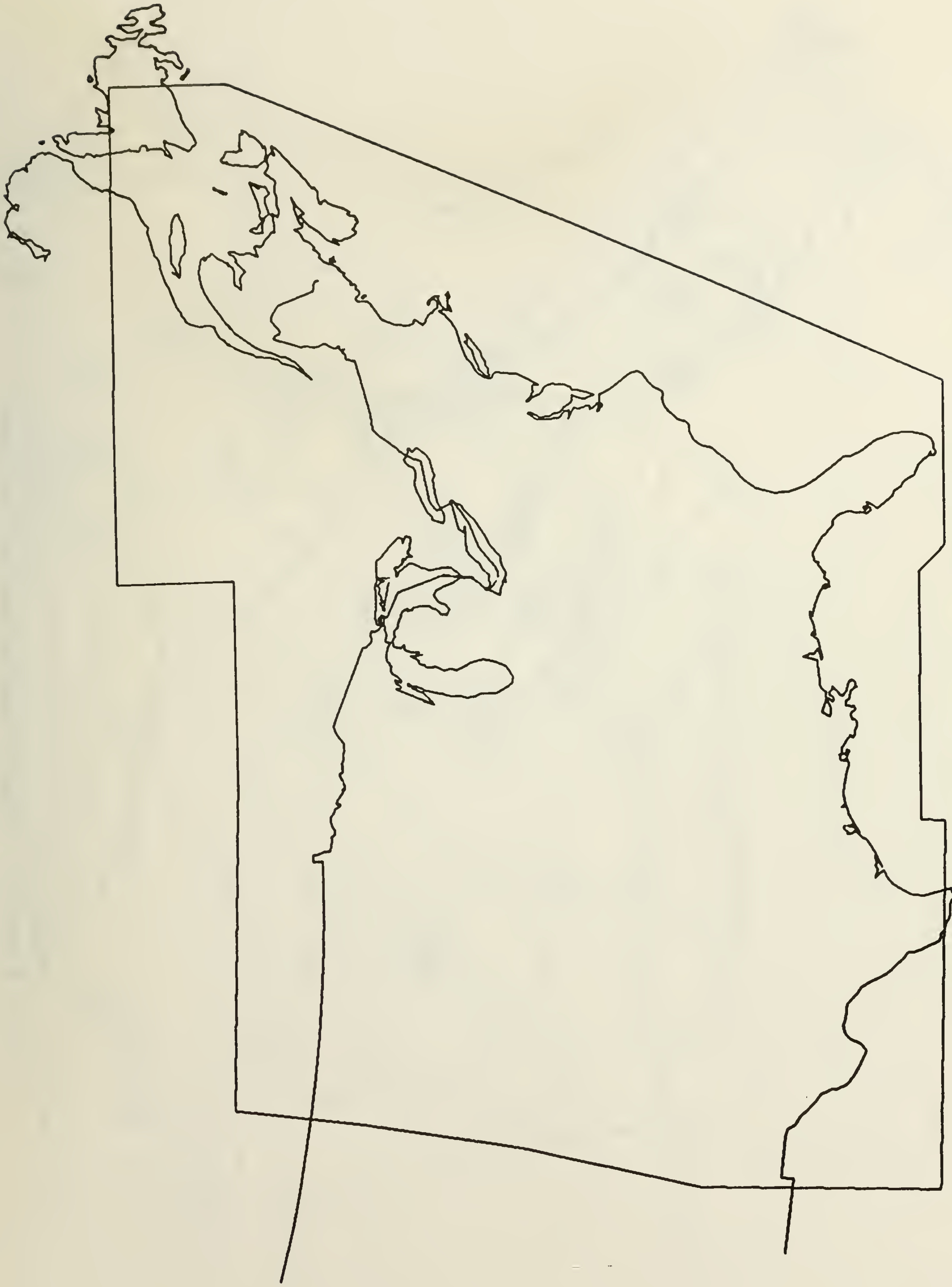

Figure B6.3 Seismic zonation map alternative 2 to Expert 6's base map.

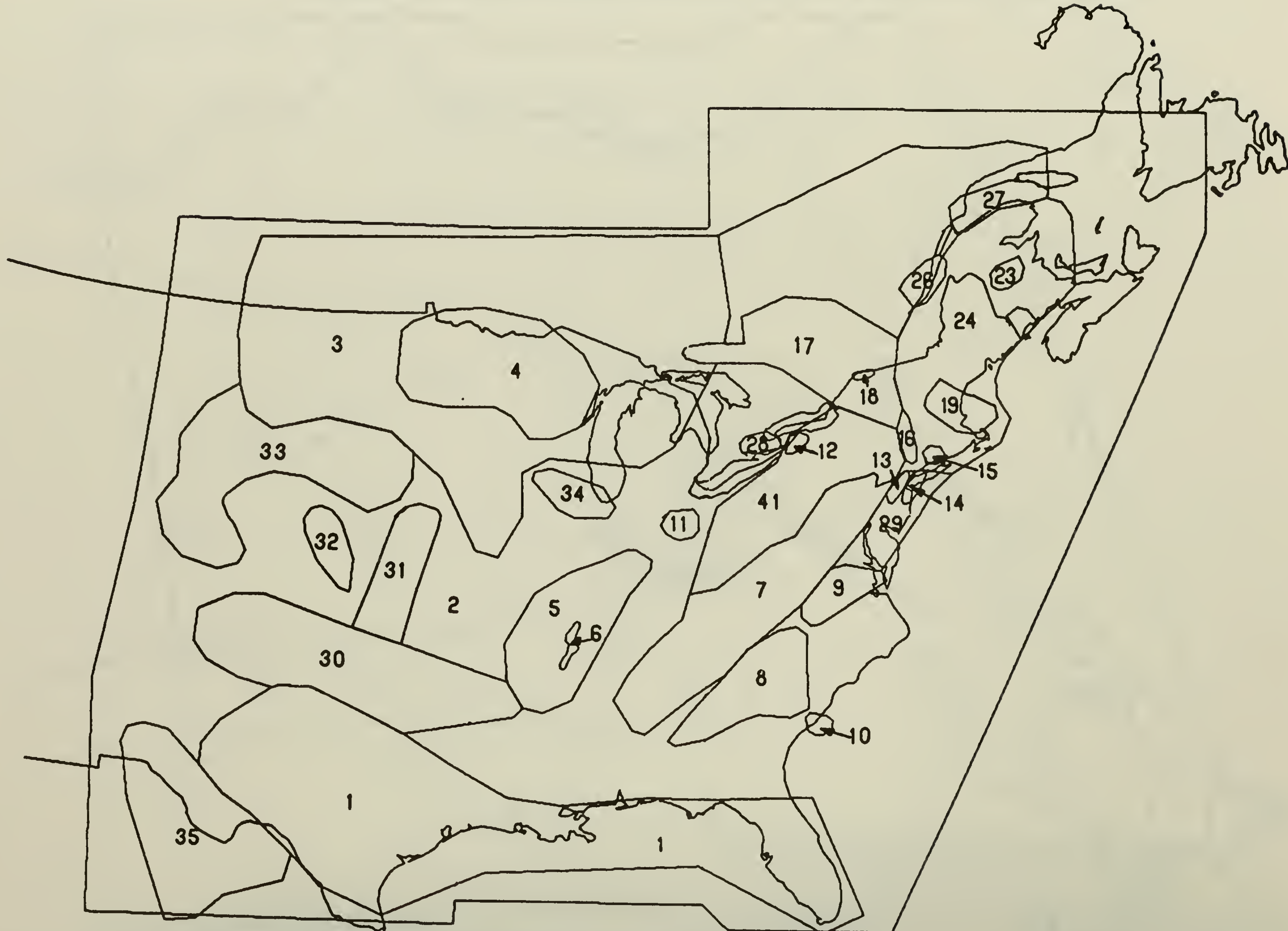

Figure 7.1 Seismic zonation base map for Expert 7.

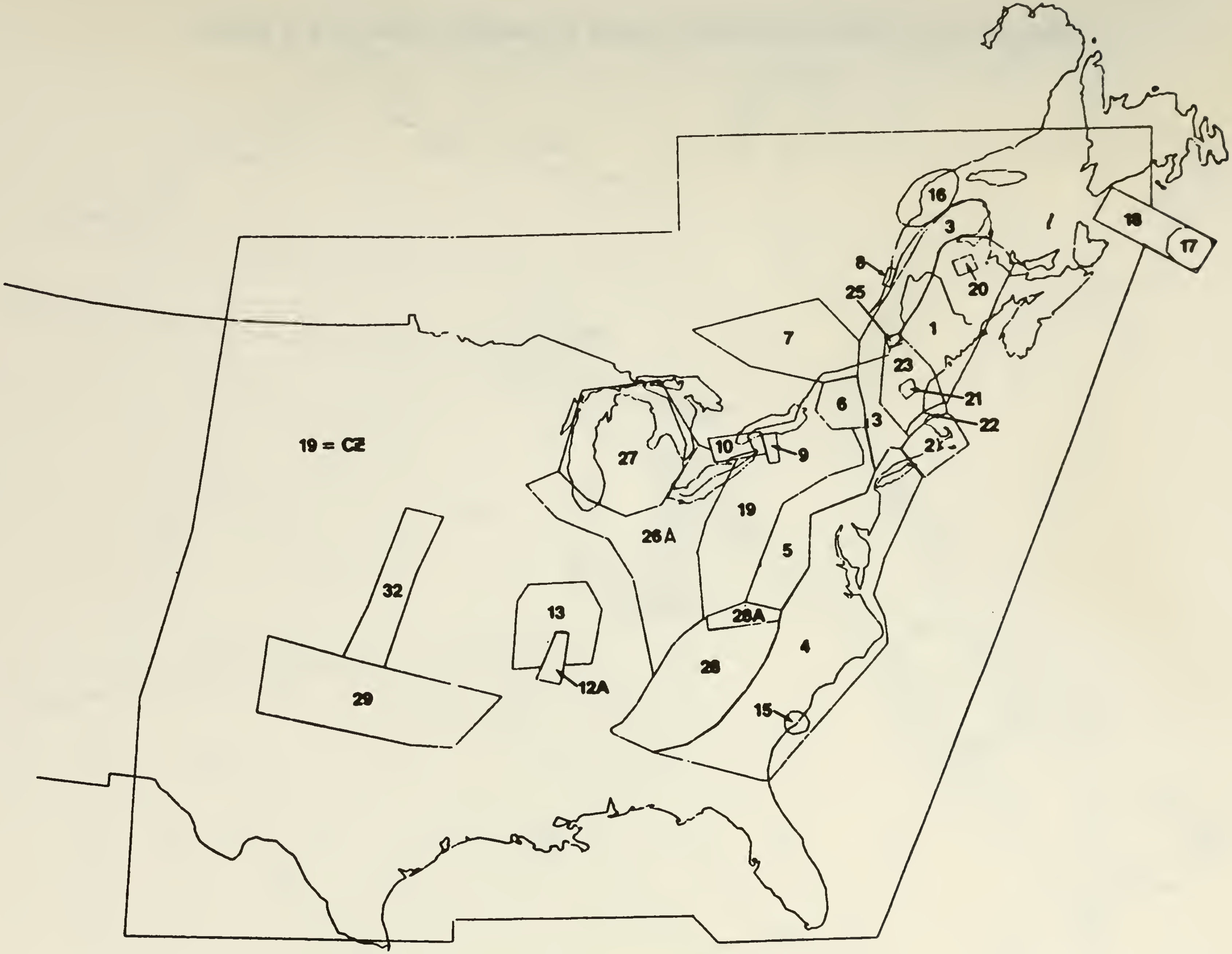

Figure B10.1 Seismic zonation base map for Expert 10.

Figure B10.2 Map of alternative seismic zonations to Expert 10's base map.

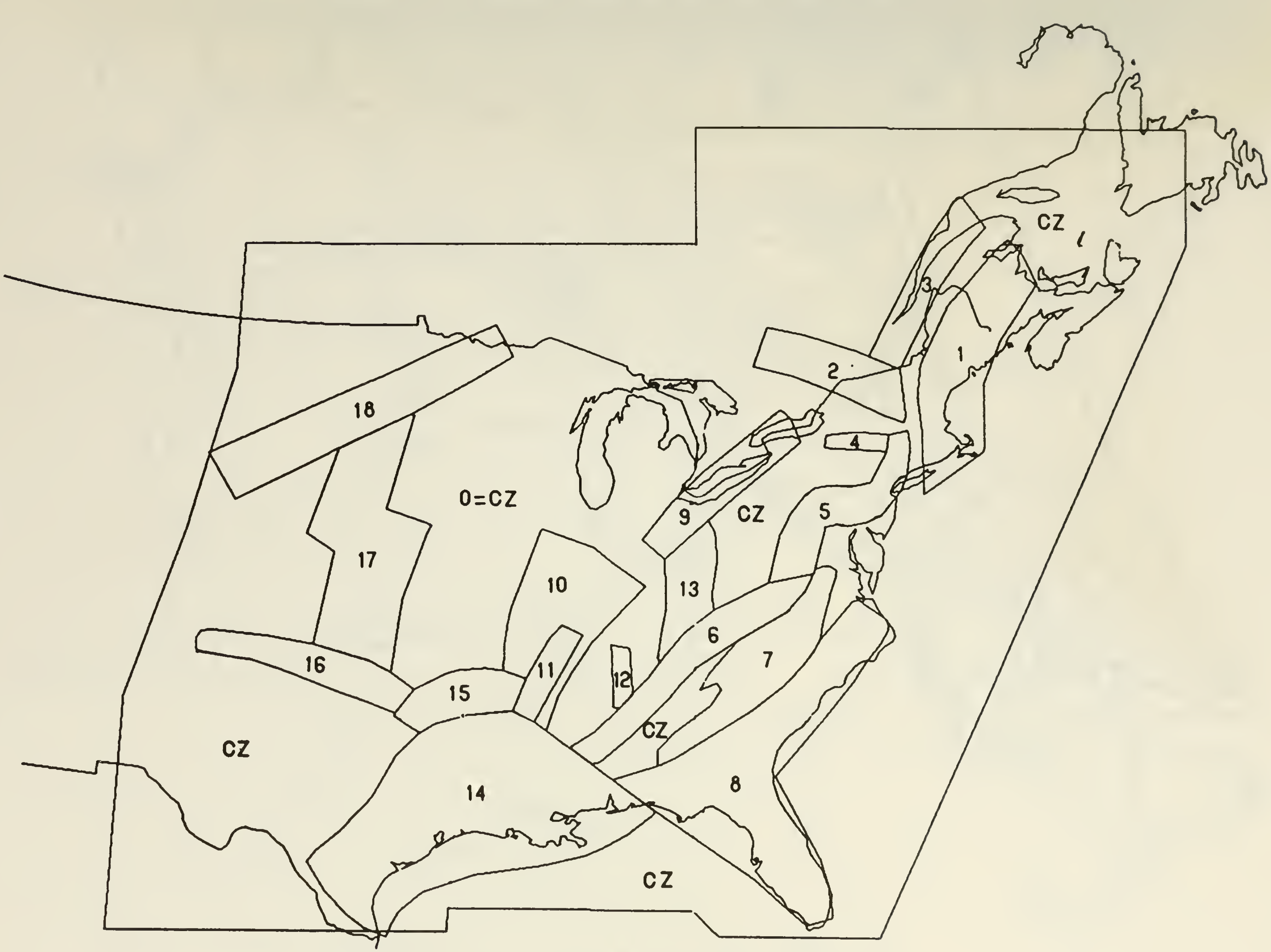

Figure B11.1 Seismic zonation base map for Expert 11.

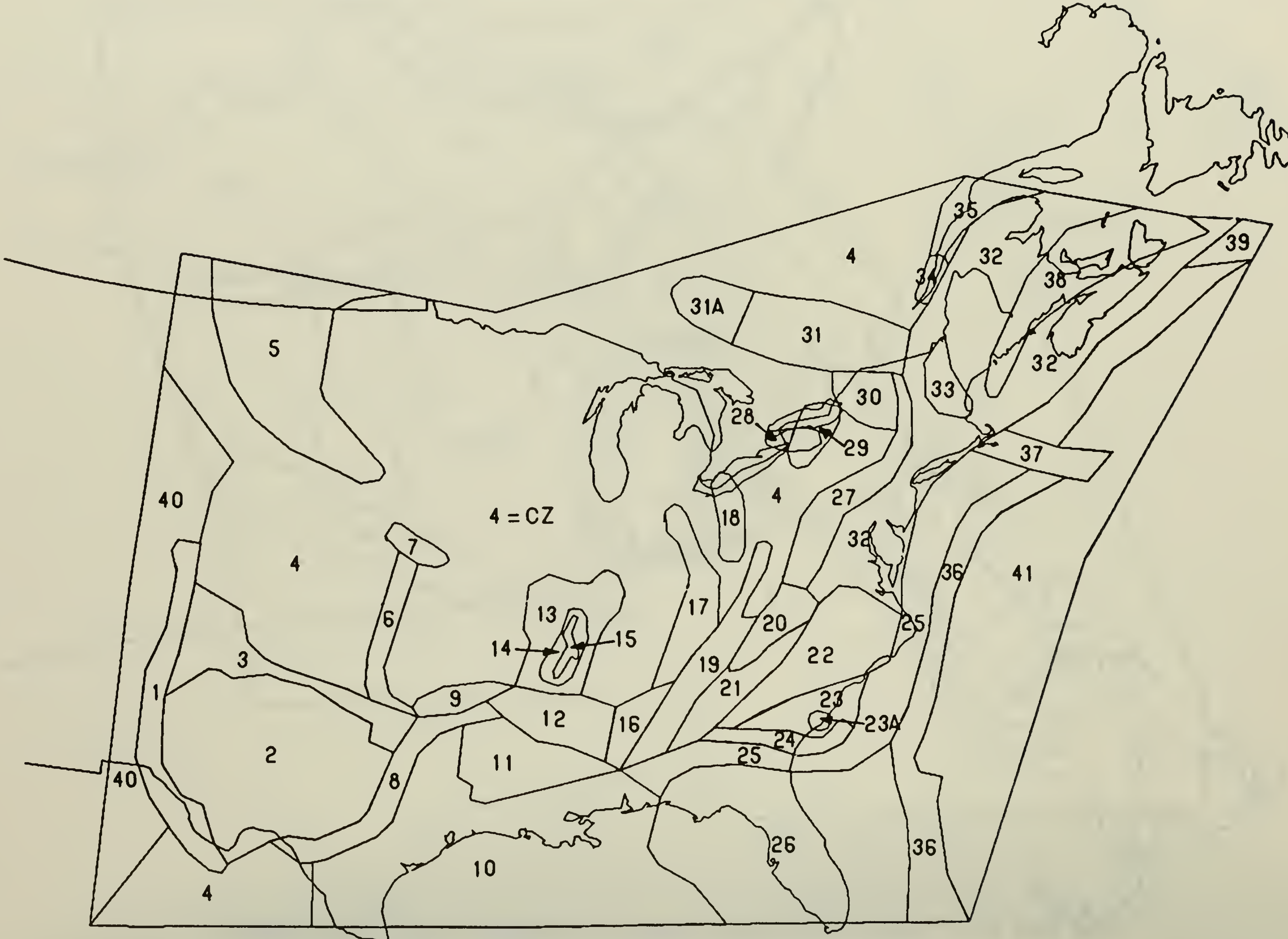

Figure B12.1 Seismic zonation base map for Expert 12.

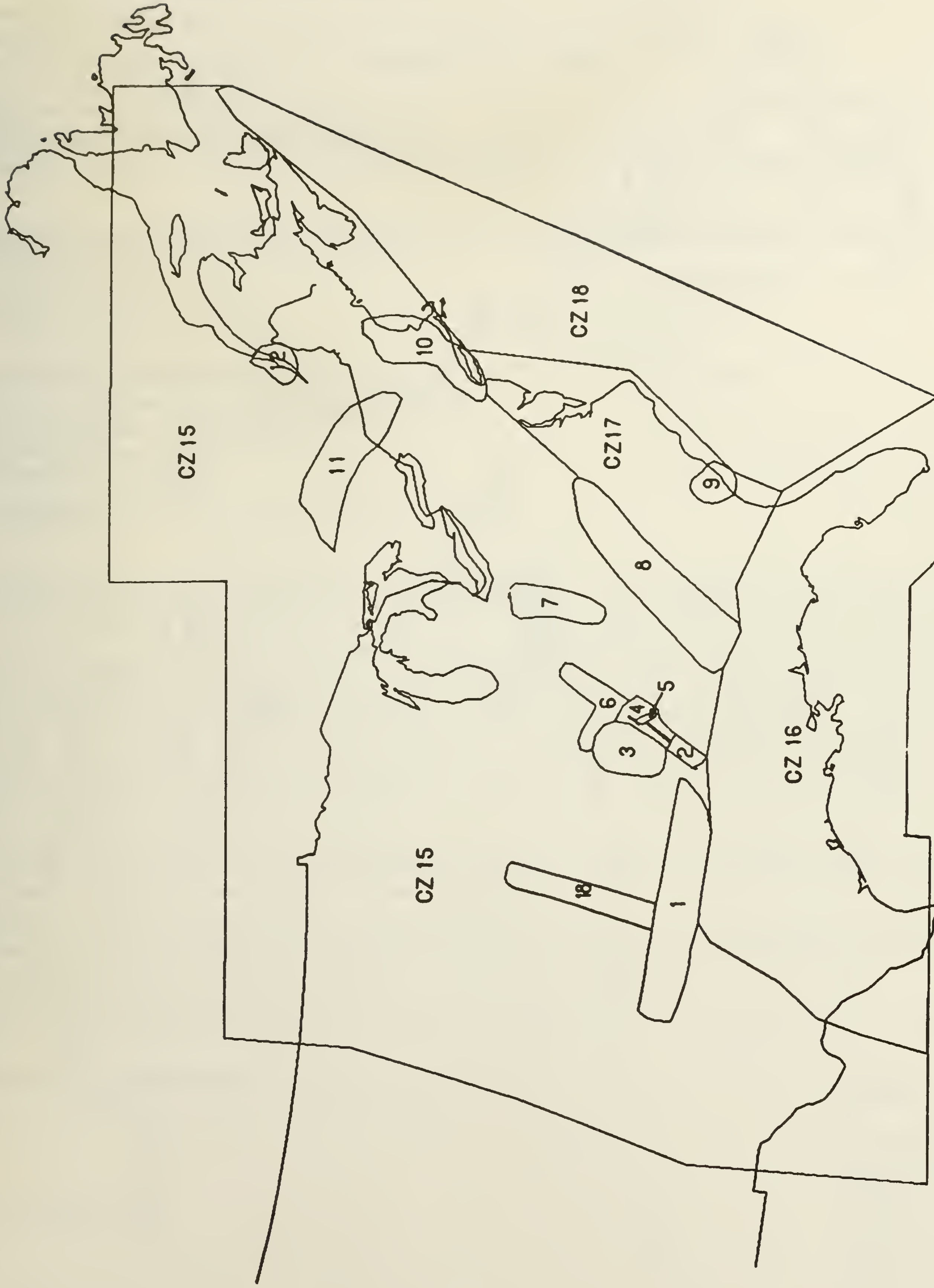

Figure B13.1 Seismic zonation base map for Expert 13.

Figure B13.2 Map of alternative seismic zonations to Expert 13's base map.

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13. ABSTRACT (200 words or less)

The EUS Seismic Hazard Characterization Project (SHC) is the outgrowth of an earlier study performed as part of the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP). The objectives of the SHC were: (1) to develop a seismic hazard characterization methodology for the region east of the Rocky Mountains (EUS), and (2) the application of the methodology to 69 site locations, some of them with several local soil conditions. The method developed uses expert opinions to obtain the input to the analyses. An important aspect of the elicitation of the expert opinion process was the holding of two feedback meetings with all the experts in order to finalize the methodology and the input data bases. The hazard estimates are reported in terms of peak ground acceleration (PGA) and 5% damping velocity response spectra (PSV).

A total of eight volumes make up this report which contains a thorough description of the methodology, the expert opinion's elicitation process, the input data base as well as a discussion, comparison and summary volume (Volume VI).

Consistent with previous analyses, this study finds that there are large uncertainties associated with the estimates of seismic hazard in the EUS, and it identifies the ground motion modeling as the prime contributor to those uncertainties.

The data bases and software are made available to the NRC and to the public uses through the National Energy Software Center (Argonne, Illinois).

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